Practical Questions on Locomotive Operating

KNIGHT

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BY

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E. L. Grimes Company, Printers, 122 Pearl St., Boston

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PREFACE.

Composing this little volume is the response to the requests of my friends and fellow-workers.

The work takes up nearly all the essential questions asked in the examinations for engineers in the Eastern District.

The first series of questions are those asked in the examination for engineers on the Boston & Maine System. The line up of the work is such that an answer to nearly any question in these examinations may be found, in addition to several useful questions and answers involving Locomotive Operation.

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PRACTICAL QUESTIONS ON LOCOMOTIVE OPERATING

CHAPTER I.

Boston & Maine Examination.

1. What is combustion?

A. Combustion is any rapid and chemical combination of the atoms of the air with any combustible material producing both light and heat.

2. What is necessary to perfect combustion?

A. A sufficient supply of oxygen is necessary.

3. What is the best method of firing a locomotive?

A. To fire light, say one or two shovelfulls at a time, consistent with the work the engine is doing.

4. Describe a blower, its use and abuse.

A. The blower is a pipe attached to the turret and its use is to produce a draught on the fire. Its abuse is the result of using it too strongly when cleaning the fire or when steam is up to the desired point.

5. Describe the dampers, their use and abuse.

A. Dampers are doors attached to the ash pan, and to regulate the admission of air to the fire

(abuse), keep closed in engine house, also when drifting down grades.

6. How does exhaust steam produce a draught on the fire?

A. When exhaust steam leaves the nozzle it is smaller in diameter, when passing into the petticoat pipe it expands sufficiently to fill the petticoat pipe and stack, displacing the air and forming a partial vacuum in the front end. The passing of steam through the stack gives a pump-like action by forming a piston of steam in the stack.

7. What effect does it have to leave the firebox open?

A. It will lower the temperature of the firebox and cause unequal expansion and leaky tubes.

8. What effect does a small exhaust nozzle have on the work of the engine, also on the fire?

A. A small exhaust nozzle will cause a sharper draught, as the steam flows at a greater velocity. A small tip will cause back pressure in the cylinders.

9. Describe a brick arch and its purpose.

A. The brick arch is made of firebrick and is supported by lugs on the side of the firebox. Its purpose is to increase the path of flame and to aid combustion by holding the gasses in firebox for a longer period, so they will be more thoroughly

mixed with the oxygen of the air and burn before escaping to atmosphere.

10. What is black smoke and how prevented?

A. Black smoke is that unconsumed part of coal sometimes called volatile matter; it can be prevented by carrying door on the latch and firing light, say one or two shovelfulls at a time.

11. How is the draught regulated in a locomotive with a straight stack?

A. The draught is regulated in a locomotive with a straight stack by a petticoat pipe and baffel plate.

12. What effect if flues become stopped up?

A. There will be a loss in heating surface and engine will steam poorly.

13. What is the effect of leaks about the smoke box?

A. Leaks about smoke box will destroy the partial vacuum in front end and engine will not steam.

14. What effect have leaky steam joints and how located?

A. Place the reverse lever in center notch, open the front end, now give the engine steam; should leaks be present, they will be seen at the joints. To test the exhaust base have a man in the cab, open the throttle slightly and reverse the lever from either corner; should the base be loose it will show up by this method.

15. How should water be carried in a boiler?

A. Water should be carried at a sufficient height to insure working dry steam, say about 2 1-2 gauges.

16. Should special care be given to maximum water level with piston valve engines, and why?

A. Yes, the piston valve, due to its construction, cannot be lifted from its seat as in the case of a slide valve after the port is closed for compression, and therefore is more liable to cause cylinder heads to be blown out in case the engine is run too full of water.

17. To what temperature is water heated to produce steam?

A. At 14.7 atmospheric pressure water passes into steam at 212 F.

18. How is steam produced in a boiler?

A. By the application of heat to water.

19. What is steam?

A. Steam is an elastic gaseous vapor; it is invisible under pressure, and it is formed by application of heat to water.

20. What does the pressure shown on the steam gauge indicate?

A. The pressure on the gauge shows pressure to the square inch (of each inch of internal area of the boiler).

21. How is it applied in a locomotive to draw a train?

A. It passes to cylinders, giving the pistons a reciprocating motion, which is transferred to a rotary motion by the connecting rod to the driving wheels.

22. Describe a locomotive boiler.

A. The locomotive boiler is cylindrical in form. It has a firebox at one end, consisting of roof crown, tube back door inside and outside sheets. The sides, back, tube and door sheets are fastened to a mud ring or foundation ring. The front portion contains the draft appliances, tubes extend horizontally from the firebox to the front end.

23. How are the firebox sheets braced to withstand the steam pressure?

A. Firebox sheets are braced by staybolts.

24. What are the different ways of staying crown sheets?

A. There are two ways of staying crown sheets; the radial stay method and the crown bars and sling stay method.

25. What is the dome for, also fountain, or turret?

A. The fountain or turret is a common connection from which steam to the air pump, injectors, lubricators and drifting valves are connected. The turret has an internal pipe extending up near the throttle valve for the purpose of delivering dry steam to its various connections. The dome is used

to elevate the throttle valve, above the water for the purpose of getting dry steam.

26. What is the depth of water over the crown sheet when it shows in the bottom gauge cock?

A. The I. C. C. requirements are 3 inches from the lowest reading of the water glass or gauge cock, plus the thickness of crown sheet.

27. Why are boiler checks applied as far forward as possible?

A. To get the water into the coolest part of boiler.

28. What causes staybolts to break?

A. Unequal expansion and contraction.

29. What effect has bad water on the boiler?

A. Bad water will cause boiler corrosion, foaming and scaling. Scaling will cause more coal to be burned as it insulates against heat.

30. What effect does mud have on boiler, and scale on the flues?

A. Flues will scale and will not conduct the heat, the engine will steam poorly, mud is apt to cause the boiler to be mud-burned.

31. Explain cause of boiler foaming.

A. Boiler foaming is caused by impure water, containing animal fats, alkli, etc.

32. What are the dangers of boiler foaming, and how avoided?

A. When an engine foams it is liable to expose

the firebox sheets and cause them to be burned. It is also liable to run the water below the crown sheet if the engine is not shut off, since water and steam are so intermingled during foaming.

33. What is meant by boiler priming?

A. Boiler priming is when the water is carried too high and carried over into cylinders.

34. What is the difference between priming and foaming?

A. Priming is due to high water in the boiler, foaming is due to inpurities in the water.

35. How does steam pass from the boiler to the cylinders and thence to the atmosphere?

A. Steam rises to the surface of the water in the form of bubbles, exploding at the surface of the water, forming steam. When the throttle is open, the steam flows through the throttle valve into the throttle pipe and is conveyed through the dry pipe to the tee in the front, and here it branches off to each cylinder through the front end steam pipes. From these pipes it passes into the steam passages in the saddle into the steam chest, through the admission ports, and when the valve is moved back by the eccentric the steam passes into the cylinder, through the steam port, and is cut off by the valve after its work is done; by expansion it passes back through this port, which is then connected to the exhaust port by the cavity of the valve flowing

through the exhaust passage in the saddle through the exhaust base, nozzle, petticoat pipe, and stack to the atmosphere.

36. What are the different makes of injectors in use on this road?

A. The most prominent makes of injectors are the Hancock and Sellers.

37. Describe the principle on which the injector works.

A. When the lever is just started steam flows through the lifting jet and out the overflow, forming a small vacuum in suction pipe and the pressure of the air on the water in tank forces it to injector. This in turn flows by the forcing jet, and after lever is pulled way open we open the forcing steam nozzle which forces the water into the combining tube and at the same time closing the overflow valve, then the speed of steam at its small diameter striking the water gives it a sufficient force to open the boiler check and allow it to flow to boiler.

38. Describe the most prominent causes of injector failures?

A. Dirty tanks, stuck check valves, air leaks in suction pipe, loose linings in feed hose, broken, worn and loose combining tubes, leaky intermediate overflow valves, bent priming nozzles. Tank covers frozen down, etc.

39. What would you examine if injector should fail to start?

A. See if you have water, look at feed hose and strainer.

40. What should you do if one injector should fail?

A. Use the other until I could locate trouble with it.

41. If both injectors should fail?

A. After trying every resort to get them to work we would have to dump the fire. In winter look out for all pipe connections, be sure and drain the tank, open blow-off cock, take out saddle cocks, etc.

42. Does water remain at the same level when throttle is shut off as when throttle is open?

A. No; water rises a little when throttle is open.

43. What would you do with a boiler checkleaking badly?

A. This depends upon the type of injector; if you have a Sellers' improved all that will be necessary is to close overflow valve. If it is a Hancock you will have to reduce boiler pressure and take down feed hose and put in a wooden plug; then close overflow valve and connect the hose up again. Sometimes checks can be seated by tapping with a hammer or pouring on cold water and tapping lightly. With the new check valve I would screw down on the spindle and cut out the check valve.

44. Is there more than one check between injector and boiler?

A. Yes, there are two checks, and sometimes three, and on some engines we have a combined check and stop valve.

45. How can you tell the difference between boiler checks leaking and injectors leaking?

A. Close the throttle to the injector, should the leakage stop, it is evident that the injector is leaking. Should it continue it would indicate the check was leaking.

46. Is there any danger in allowing gauge cocks to become stopped up?

A. Yes, because we could not determine water level in case the water glass broke.

47. What is the purpose of the water glass and what attention should it receive?

A. It shows the amount of water in the boiler; should be kept clean and guarded.

48. Why is it a bad practice to carry water too high in the boiler?

A. It will work over into the cylinders and is liable to blow out cylinder heads, and will wash oil from the valve seats.

49. What causes tanks to sweat, and how prevented?

A. Tanks sweat in warm weather, and the reason for this is due to the water being cooler than

the atmosphere which contains moisture and condenses upon the tank. To prevent take off the cover on the manhole, put on the heater and warm the water slowly.

50. How and by what means are valves, cylinders and air pumps lubricated?

A. By a sight feed lubricator.

51. How should the lubricator be filled?

A. After the lubricator has been shut off and allowed to cool, open the drain and draw off the water, then fill it with warm oil, leaving ample room for the oil to expand.

52. Describe the manner in which a sight feed lubricator works.

A. When steam and water and feed valves are open the weight of water in condenser pipe and the oil being lighter than the water flows to the top of oil chamber, the oil then flows through the U-shaped tubes to bottom of feed valves, passes through the glass to choke plugs and steam at this point forces it to cylinders through the oil pipes.

53. What would you do if one glass should break?

A. If one feed glass should break shut off the water and feed valves and oil through independent oiler; keep using lubricator for the other cylinders.

54. Where are the choke plugs and what is the object of them?

A. Choke plugs are at the rear of the lubricator near the top feed arms; sometimes in the oil pipe near the steam chest. Their object is to force oil to cylinders, and to regulate flow of oil into the cylinders.

55. If the glasses fill up, how can you clean them out?

A. By opening blow-out valve under the glass.

56. When valves appear dry, when using steam, and lubricator is working all right, what would you do to relieve conditions?

A. Partly close the throttle, and drop the lever near the corner for a short time, thereby reducing steam pressure in steam chest.

57. Why is it a bad practice to keep engine oil close to a boiler in warm weather?

A. It will become too warm and lose its lubricating quality.

58. In what manner would you care for hot bearings when discovered on the road, and what kind of oil used?

A. Hot eccentrics loosen up on the strap bolts and insert a piece of tin and tighten them up again. Hot lead and tender trucks use hard cup grease and water. In order to get into your terminal soak a pail of water into the box after packing it with cup grease around the journal. All oil holes should be looked after and kept cleaned out.

In case of hot driving boxes, release the weight by blocking between the spring saddle and frame, run the wheel with the hot box up on a wedge to get the engine up far enough to the block. Should the engine be underhung chain the end of the equalizer up the frame next to the hot journal.

VALVE MOTION.

59. How many styles of valve motion are there on this road?

A. There are two styles.

60. What are they called?

A. The Stephenson and the Walschaert Valve Gears.

61. Describe the Stephenson Gear.

A. The Stephenson Gear consists of two eccentrics which are keyed to the shaft, it has rods connected to the link, and the motion is transmitted to the valve by the eccentric link, link block, rocker arm and valve rod; the link is movable and is suspended by a link, hanger link saddle and saddle pin. (Stephenson Gear is floating link motion.)

62. Describe the Walschaert Gear.

A. The Walschaert Gear consists of an eccentric crank or arm attached to main pin, the motion is given to the link through eccentric rod attached to bottom of the link, which is transmitted to the valve through

the radius rod and combination lever. When going ahead we have direct motion, when backing up we have indirect motion. The Walschaert is a stationary link motion, and we change from forward motion to back by the indirect motion of the link. The combination lever gives the constant lead by shortening or lengthening the eccentric throw on the centers.

63. What advantage has the Walschaert Gear over the Stephenson Gear?

A. The Walschaert Gear is easier to inspect, repair; gives chance to brace frame, and is much lighter.

64. Describe a piston valve.

A. A piston valve is a spool-shaped valve, having packing rings on its ends and moves in a removable bushing.

65. Describe a slide valve.

A. A slide valve is a rectangular valve, which has a D-shaped cavity in its under part, with groves on top to receive packing strips which are held in place by eliptical springs, these strips are held against the pressure plate or balancing plate; a hole is drilled into the cavity to relieve any leakage of steam by the packing strips.

66. What is meant by steam lap and its use?

A. Steam lap is the amount the valve overlaps the steam ports when in central position. It is to aid in working steam expansively.

67. What is meant by exhaust lap and its use?

A. Exhaust lap is the amount the valve overlaps the steam ports on the inside when the valve is in central position. Its use is to get more expansion and a greater compression.

68. What is meant by exhaust clearance?

A. Exhaust clearance is the amount the steam ports are open to exhaust port when valve is in central position, or the amount the inner edge of valve fails to cover steam ports in central position.

69. What is meant by lead?

A. Lead is the amount the steam port is open at the beginning of the stroke.

70. What is meant by inside and outside admission valves?

A. An inside admission valve takes steam on the inside and exhausts on the ends. An outside admission valve takes steam on the outside and exhausts it in the middle or inside.

71. How and why are slide valves balanced?

A. Slide valves are balanced by packing strips held against a pressure plate by eliptical springs. If valves were not balanced there would be a great pressure on top, as the under side is always open to the atmospheric pressure nearly.

72. What is the difference in the valve motion for outside admission valves and inside admission valves?

A. We have a direct rocker arm for inside admis-

sion and an indirect rocker arm for outside admission valves.

73. What does the term "cut-off" mean?

A. At that point of the stroke where the valve cuts off the admission of steam to the cylinder.

74. What is the purpose of the link?

A. The link serves as a means of reversing the engine and to regulate the cut-off.

LOCOMOTIVE RUNNING.

75. What are the engineer's duties before starting out with an engine?

A. To examine work, book and see if any repairs have been reported on the engine, and see if they have been made; examine the bulletin boards for new orders, etc.; see if we have proper supplies; give engine thorough inspection; register out; see that he has the correct time.

76. What tools and supplies should be on the engine?

A. The engineer's tool box, flags, lanterns, torpedoes, fuses, necessary coal and water, wedges, blocks, etc., in case of breakdown; the proper tools for attending to fire and sand.

77. What are the engineer's duties when coming in with an engine?

A. Make a thorough inspection of the engine,

report any defects if found; leave engine with good fire and plenty of water for the hostler.

78. What is the most economical practice in working steam?

A. Working steam expansively.

79. What are the advantages of working steam expansively?

A. Economy in fuel and water.

80. How would you detect a leaky throttle valve?

A. By closing throttle and opening cylinder cocks; should steam show it is evident the throttle valve leaks.

81. How would you detect a leaky dry pipe?

A. By closing throttle valve, opening cylinder cocks, should steam and water show it is evident that dry pipe is leaking. Be sure and have the boiler well filled with water before testing.

82. How would you set up a wedge?

A. Place the engine on a straight and level track and have engine on top quarter on the side you are to set up wedge; then set tender brake; put lever in forward gear and give the engine just enough steam to pull the driving box away from the wedge; then raise wedge as far as it will go and slack it back about one-eighth of an inch to guard against it sticking.

83. How would you key up a main rod? Why in those positions?

A. To key up a back end place engine on the top quarter, slack the set-screw, and the drive key. Then move engine to top forward eight, as this sometimes is the largest diameter of the pin, and see if it is all free, and you can move it sideways. Key in this position because all that will be necessary is to move the brass and the weight of main rod will be on the opposite brass due to the angle. Key the forward end on the bottom quarter, and key in like manner move to the center, as it might be larger at that point. Why in that position? Because the weight of main rod is on the forward brass and the brass near the key will move easy.

84. How would you locate a pound in a locomotive?

A. Place the engine on the top quarter on the side you are going to look for the pound; set the tender brake; have the fireman give the engine a little steam and work lever from front and to back corner and watch driving boxes back and forward ends; cross head shoes; also see if the saddle key is all right.

85. Why place engine in that position?

A. Because you can get steam in both ends of cylinder. You put it on top quarter so all that will be necessary is to rock the driving wheel, whereas, if you put engine on bottom quarter you would have to move engine itself. Before the slack was taken up.

86. How can a wedge be kept in position when a wedge bolt is broken?

A. A wedge can be kept in position when bolt is broken by pushing it up and wiring a nut on the pedestal brace and around the jaw.

87. How would you work an engine with a heavy train and a bad rail, and why?

A. It was recommended some time ago to run a light throttle and a long cut off, but this does not work out in practice. On English roads it is recommended to hook the engine up short and use a moderate throttle. Experience shows this to be a good method.

88. What would you do if tank valve should become stuck shut?

A. Would try and blow it from its seat, using the injector. If it could not be done in this way, take feed hose down and run a stick up into the hose and unseat it and quickly connect up the hose.

89. How would you test for a blow in a main valve?

A. Place engine on the quarter (top preferred) and cover ports with the valve, open the throttle, if steam escapes from the stack the valve packing strips are leaking. Test for a cut seat in same manner, but open cylinder cocks. If steam shows there the valve or seat will be cut. If an engine has inside clearance you might get a cylinder cock blow in this position and valve seat be tight. But such a blow would be indi-

cated more in the stack. Best way to locate a blow of this kind and this type of valve would be to incline lever until steam port is surely closed, say about the second notch, then open one cylinder cock on that side, opposite to the side that has steam.

90. How would you test for a blow in cylinder packing?

A. A cylinder packing blow will show when starting the train; it will blow hard up to point of cut-off and from there to end of stroke much lighter. To test place the engine on the quarter lever in corner and open throttle, then open the cylinder cocks. Should steam show at both cylinder cocks it will be evident that piston packing leaks on that side.

91. How would you locate on which side the packing strips were down?

A. Go in under the engine open the saddle cocks, the one that shows steam will indicate on which side the strips are down.

92. How should sand be used when a locomotive is slipping?

A. The engine should be shut off until it stops slipping and sand applied and throttle opened again.

93. What is the danger of using sand on one side only?

A. It is liable to strip the engine.

94. At what points is a locomotive's weight supported when in working order?

A. On the mogul and battleship type on fulcrum points of equalizers; on passenger engines fulcrum points of equalizers and lead truck center bearings. A 10-wheel engine has four fulcrum points; a standard engine has two fulcrum points.

95. What is a compound locomotive?

A. A locomotive that uses its steam two times expansively.

96. What is the advantage of this type of locomotive over the simple?

A. Economy in fuel and water.

97. Why is one cylinder on a compound locomotive called high-pressure cylinder and the other one low-pressure cylinder?

A. High pressure takes steam from boiler and low pressure cylinder from the high-pressure cylinder.

98. In the Schenectady two-cylinder compound, what is the function of the oil dash pot?

A. To keep the intercepting valve from slamming.

99. Is it necessary to know that the dash pot is filled with oil, and why? What kind of oil should be used?

A. Yes; if it is empty it will cause it to slam and even break it. Black oil is used.

100. Explain how a Schenectady two-cylinder compound may be operated as a simple engine.

A. By placing the valve leading to intercepting

valve in simple position, which opens the separate exhaust valve.

101. When should a Schenectady compound be operated as a simple engine?

A. When starting a train.

102. Why not operate as simple when running fast?

A. The engine would be apt to strip itself. The boiler would not make steam enough.

103. Explain how a two-cylinder compound engine is changed from simple to compound.

A. By placing the simpling valve to compound position, allowing separate exhaust valve to close.

104. How much water should be carried in a boiler of a compound, and why?

A. About ½ glass, should you work wet steam it may all condense before it gets through low pressure cylinder.

105. What should be the practice in starting compound engines?

A. Start simple and have cylinder cocks open when the train is started at say about 4 miles per hour; then change to compound.

106. Where is the separate exhaust valve?

A. In the saddle in front of the intercepting valve.

107. Is the separate exhaust valve open or closed when the engine is working simple?

A. Separate exhaust is open when working simple.

108. What opens the separate exhaust valve?

A. Separate exhaust valve is opened by air from main reservoir.

109. Trace the flow of steam from the boiler to the cylinders and thence to the atmosphere when engine is working compound and when simple.

A. The flow of steam with the R. I. and Schenectady compound when working compound is the same as the simple engine, from boiler to Tee in front end, then it passes through a small steam pipe to the intercepting valve, at the same time through the large steam pipe to the high pressure steam chest. It is then admitted to the cylinder by the valve through the steam ports. After the steam has done its work it passes out through the same port, through the cavity and exhaust port under the valve into the receiver. This carries the steam over to the intercepting valve, through which the steam flows to the low pressure steam chest. It is now admitted to the low pressure cylinder by the valve through the steam ports. When it has done its work it passes out through the same port, through the exhaust cavity and port under the valve to the exhaust passage in the saddle, exhaust pipe, exhaust nozzle and stack to the atmosphere.

When working simple steam comes from the niggerhead or tee as before, flowing through the large steam pipe to the high pressure steam chest, and is admitted to the cylinder by the valve through the

steam ports. After it has done its work, it passes back through the same port into the exhaust cavity under the valve, through exhaust port into the receiver, to the intercepting valve, out through the separate exhaust valve to the exhaust cavity in saddle, exhaust pipe, exhaust nozzle to the atmosphere. The low pressure side gets its steam from the tee in the front end, through the small steam pipe, the steam flowing through the reducing valve inside of the intercepting valve to the low pressure steam chest. The steam is now admitted to the cylinder by the main valve through the steam ports; after the steam has done its work it passes back through the same port to the exhaust cavity and port under the valve, through the exhaust passage, exhaust nozzle and stack to the atmosphere.

110. Why is it more important to have cylinder cocks opened when starting a compound engine than a simple engine?

A. Steam may condense before it gets through low pressure cylinder, and is apt to blow out a cylinder head.

111. If it become necessary to disconnect a compound on the high pressure side, what should be done? On the low pressure side?

A. Disconnect same as you would with a simple engine and work engine simple.

ACCIDENTS TO LOCOMOTIVES.

112. What would you do first in case of breakdown on the road?

A. In case of break-down on road, I should see that the train was properly protected.

113. How are accidents and break-downs best prevented?

A. By a careful inspection of the locomotive.

114. In what relation do the eccentrics set relative to the crank pin?

A. The forward motion eccentric should follow the pin at right angles, less lead and lap of the valve. The back-up motion should lead the pin at right angles, less the lead and lap of the valve.

115. How are they kept in their places on the axles?

A. They are kept in place by a spline and set-screws.

116. How would you detect a slipped eccentric?

A. By the engine going lame or badly out of square.

117. Would you put water on a hot eccentric?

A. No; such a course would either break strap or injure it so it would be useless.

118. How would you set a slipped eccentric?

A. First method: Place engine just a little be-

low back center (for setting go-ahead eccentric), let eccentric drop down to its lowest point and secure it. The back-up should be set just below the forward center and secured as above.

Second method: For a go-ahead eccentric, place engine on forward center and the lever in the back gear, mark valve stem at the gland; now put the lever in forward gear, go in under the engine and revolve eccentric until the mark on valve stem coincides with the gland and secure it.

Eccentric may be set also by the cylinder cocks, but the above are the most handy.

119. How would you disconnect with a broken eccentric strap or rod?

A. Broken eccentric strap or rod, take down both eccentric straps and rods on the disabled side, tie the link to the end of lifter, clamp valve with a little forward port opening, take out forward cylinder cock, increase lubrication on that side.

120. Broken reverse lever or quadrant?

A. Broken reverse lever or quadrant, fit a block in the top of the link above the link block on one side to hold the link so the engine will start the train. Loosen the nuts on balance spring, so the link will not jump off from the block.

121. Broken reach rod, reverse arm?

A. Broken reverse lever or quadrant, remove

broken parts and proceed to block as you did with broken reverse lever or quadrant.

122. Block on how many links, and why?

A. Block on one link only, as other side conforms to that block; if two were used one might fly out when running.

123. Broken tumbling shaft?

A. Remove the broken parts, disconnect the link hangers, put the reverse lever in full black gear. This will bring the right hanger and lifter out of the way. Now pull out the broken portion of the tumbling shaft, next block the links where the engine will start its train, fit these blocks between the link block and the top of the link, allowing a good margin for starting the train in bad places.

124. Broken lifting arm, link hanger, saddle, or saddle pin?

A. In all three breaks the broken parts should be removed and the link hangers taken off, the link should be blocked where engine will start the train; the reverse lever secured so it cannot be moved, as the lifters would hit the link and lead to further damage.

125. Broken transmission bar?

A. Remove broken parts, clamp valve with a little forward port opening for lubrication, oil guides well; take out front cylinder cock.

126. Broken link block pin?

A. If link will not clear the lower rocker arm, take down both eccentric straps and rods, clamp valve with a little forward port opening for lubrication, oil the guides well. If the link clears the rocker arm and only short distance to go leave it up.

127. Broken lower rocker arm?

A. Same as 126.

128. With one link blocked, what would you guard against?

A. Reversing engine and dropping the lever in the corner.

129. Broken rocker shaft, top rocker-arm, and valve stem?

A. Disconnect valve rod and take out the broken shaft and top rocker-arm; if there is enough left of the rocker shaft to hold bottom rocker-arm it will run O. K.; if in doubt take it out; leave main rod up as before stated; crack front port for lubrication. If you take out the bottom rocker shaft take down both eccentrics, straps and rods if any distance to go.

130. In case a slide valve yoke, or stem becomes broken inside of steam chest, how can the breakage be located?

A. It will be discovered by engine working against itself or bucking badly. Place the crank pin on top or lower quarter if you can and reverse the

lever forward and back; if steam comes from one cylinder cock only you may know that it is on that side.

131. After locating a breakage of this kind, how would you proceed to put the engine in safe running order?

A. If there is a relief valve on front of the steam chest set rocker-arm straight up and down, take out the relief valve, push the valve back until it strikes the stem and it will be central, then fit a block or stick in relief valve long enough to hold valve back, when relief valve is screwed in again, clamp valve stem, take down valve rod; and if there is no relief valve in front of the steam chest the cover would have to come up and valve blocked central. Fit this back to give the valve a little forward port opening for lubrication; take out forward cylinder cock.

132. Broken main slide valve, valve seat, and steam chest?

A. Take off steam chest cover, take out the valve, block over steam inlet ports to the chest, having blocked high enough so when the cover is put back on it will hold the blocking in place; take out both cylinder cocks. If it is an old style saddle where steam enters at side of the chest, I would put a blind gasket in the joint between the steam chest and saddle.

133. Broken crosshead or guides?

A. Take down valve rod, clamp the valve central, take down the main rod and crosshead blocked ahead. Both cylinder cocks should be taken out, secure piston by tieing it forward by rope or chain. This can also be blocked by steam tieing a rope or chain around as above to guard against it working back when steam is shut off; if you do this close the cylinder cock on the side of the piston that has steam.

134. Broken piston? Piston rod, and forward cylinder head?

A. Any of these defects will usually take out the front cylinder head, assume this to be the case, disconnect the valve rod clamp, the valve central, remove the broken parts, take down the main rod. block the crosshead back, but, however, should it be the forward cylinder head only, disconnect the valve rod clamp, the valve with a little back port opening for lubrication, removing the back cylinder cock, oiling the guides well. A broken piston, take off the broken parts, clamp the valve central. If a short distance to go leave the main rod and eccentrics up.

135. Loose follower bolt—how would you locate it?

A. Loose follower bolt would be at once detected by a bad pound while engine was drifting.

136. What would you do with a loose or broken follower bolt?

A. The engine should be stopped at once, the cylinder head taken off and bolt tightened or removed.

137. Broken side rod, eight-wheel engine?

A. Remove broken rod, also corresponding rod on the other side.

138. Broken side rod, ten-wheel engine, back section? Front section?

A. Back section: Remove broken rods and corresponding section on the other side. Front section: Remove all side rods.

139. Broken main crank pin?

A. Disconnect the valve rod, clamp the valve central, take down the main rod and all side rods, block crosshead back and take out the back cylinder cock.

140. Broken driving spring overhung engine?

A. The engine should be raised up level with jacks or wedges, block over back driving box to carry the engine level. If it is the main spring take it out and block up the front end of the equalizer.

142. Broken driving spring or hanger, underhung engines?

A. Raise the engine up with a wedge or jack, block over the back driving box and chain the equalizer to the frame on the side next to the

broken spring or hanger. A convenient way to raise the engine up in case of a broken spring or hanger, for instance a back spring hanger. Place a wedge in front of the main driver on that side and run the engine up on it. Since the driving box has the main frame resting on it, the wedge will lift the entire engine on that side and a space will be found between the back driving box and engine frame into which the block is to be placed. After doing this pry the equalizer up and chain it to the lower rail of the frame.

143. Broken equalizing beam?

A. Run the main driver up on a wedge or jack up the main frame under the cab riser and block over the back driving box. Should this be the old style engine equalizer or overhung type block between the broken end and the main frame, this giving the engine some use of the back driving spring. Should this be an underhung engine, jack up in like manner and chain the broken equalizer to the frame. (B. & M. R. R. only.)

144. Broken engine truck center pin on Mogul?

A. Put piece of a tie or rail across front of the engine frame and chain forward end of long intermediate equalizer to it, block over forward drivers.

145. Broken intermediate equalizer on Mogul?

A. Raise the engine up to its normal position, block between cross equalizer and the boiler, or

chain cross equalizer to frame would serve. If you do not want to use springs first remove broken parts and block over forward drivers.

146. Broken front tire on Mogul?

A. Run the forward pair of drivers up on wedge or jack them up to clear the rail, remove the oil cellar and fit a block in its place. Cut one side of this block to fit the journal (half round) and when the engine is raised up in this position it will fit snugly between the pedestal brace and journal, placing some oily waste before putting it in finally. While the engine is in this position block between the spring saddle and frame to take the weight off from this pair of drivers, cut out the driver brake. Should the side rods be injured and interfere they would have to be taken down.

147. Broken driving axle, eight-wheel engine, outside of driving box?

A. Generally taken in the examination as a back driver; if so, jack engine up above its normal position, take out the oil cellar and fit a block that will bear evenly upon journal (half round), then put some oily waste between this and the journal. Put a short tie or rail on the footboard, put a chain around the tie or rail and around brace on frame under footboard, raise up the back end of the tie to take up slack of the chain and block between the tie and tender; block under tender springs to keep from breaking them

down. Next chain around engine frame on disabled side and fasten to opposite side of the tender to keep the good flange against the rail; be sure and have chain wedged up tight. Disconnect side rods on both sides, put collars on good main pins, cut out driver brake and block between spring saddle and frame over broken driver to get use of good main springs. Now let engine down and tender will carry part of its weight.

If a main driver is broken outside of the box, disconnect the valve rod, clamp the valve central, take down the main rod and both side rods. Block the cross head back and take out the back cylinder cock. Jack the engine up level and block over the back driving box to carry the engine level. Then jack up the broken axle, take out the cellar and place hard wood block between the axle and the pedestal to hold the axle level. Oil this block well and proceed carefully.

148. Broken main driving axle, ten-wheel engine, outside of driving box?

A. If broken outside of box, disconnect the same as with an eight-wheel engine. Jack up broken end of axle and take out celler, fit a block between the axle and pedestal, put a block between the spring saddle and the frame to transfer the weight from this wheel to the others. If the front and back springs are not strong enough to carry the weight, then you would

have to jack up the back end of the engine and block over back box.

149. How do you cover ports with valves?

A. Generally by plumbing rocker-arm, but should it be broken move valve stem forward as far as it will go, then mark it by the gland, and then move back as far as it will go and mark in same manner, and the middle point between these two marks set at stuffing box will bring valve central.

150. Broken back tires?

A. Back driving tire. Raise the engine up a little more than level to allow for settling. Jacks or wedges could be used. Put a tie or short piece of rail on the footboard, put a chain around the tie and through the brace of the frame under the footboard. Raise up the back end of the tie to take up the slack of the chain and block between the tie and tender. Block under the tender springs so not to break them down, then let the engine down and the tender will carry part of its weight. Jack up the axle with the broken tire, remove the celler and fit a block between the axle and the pedestal, and put a block between the spring saddle and the frame. Then put a chain from the disabled side of the engine to the opposite side of the tender and twist it up tight to keep the flange of the good tire against the rail and cut out the driver brake and proceed with care.

151. Broken tire on trailing wheel on Atlantic type engine?

A. Do just the same as for back tire on a ten-wheel engine.

152. Broken engine truck axle on Mogul, and four-wheel truck?

A. The quickest way to get out of this break-down is to chain engine truck axle to a tie placed across the engine frame when engine is down, then put a jack under breast beam, raise engine to its normal position and block over forward drivers. Be sure the good wheel clears the rail.

Four-wheel truck. Jack up the front end of the engine, remove the wheels if necessary; jack up the truck frame and chain it to the engine frame. To relieve some of the strain from the chains, put blocks between engine frame and truck frame over or near the good axle.

153. Broken tender wheel or axle?

A. Should the wheel be broken, it is sometimes convenient to place a tie across the tender truck frame and allow the broken part of the wheel to run up to it and chain it securely to the axle. This will allow you to slide this pair of wheels to clear the main line. Should the axle be broken, place a rail or tie across the tender blocking it up to clear the tank dicky and chain the truck frame to it, cut out the tender brake, proceed into the first siding.

154. What would you do with a bursted flue?

A. A flue that had burst or was leaking badly should be plugged. If I could not use an iron plug, would take a long piece of wood and taper the end to fit, drive it into the flue and let it burn off.

BREAK-DOWNS—WALSCHAERT VALVE GEAR.

155. Broken eccentric crank or rod?

A. Take off the broken parts if you can block the radius bar in the center of the link and let the combination lever and union link stay up. This will give you lap and lead travel of the valve and will help you in starting your train and realize some of the power on the broken side. Should you be unable to do this clamp the valve with a little forward port opening for lubrication, taking out the front cylinder cock. Then tie the forward end of the radius bar up to the running board, let the rear end ride in the bottom of the link, take off the broken parts, disconnect the suspension bar oil guides well.

In all Walschaert valve gear brake-downs be sure the combination lever clears the cross-head and wrist pin.

156. Broken radius bar?

A. Discount the broken parts, clamp the valve

with a little forward port opening for lubrication, take out the forward cylinder cock. Tie the broken end of the radius bar up to the running board and block the back end central in the link.

157. Broken combination lever?

A. Discount the broken combination lever and the union link. On some engines the radius bar can be fastened on to the valve stem at the connection used by the combination lever; if so do this and the result will be the use of both sides of the engine. This may make the engine a little out of square but you can get into your terminal all right. Should you not be able to do this you will have to take down the combination lever and union link clamp, the valve with a little forward port opening for lubrication, block the radius bar in the center of the link and tie up the forward end to the running board. Disconnect the suspension arm or hanger, increase lubricator feed on that side, take out the forward cylinder cock.

158. Broken crosshead arm?

A. Disconnect just the same as in 157.

159. Broken suspension arm or hanger?

A. Disconnect and block the same as with a link hanger in the Stephenson valve gear.

160. Broken reverse arm?

A. Disconnect and block as in the Stephenson gear for reverse arm.

AIR BRAKE.

1. What is an air brake?

A. A method of stopping trains and operated by compressed air.

2. What is the standard air brake in use on this road?

A. Westinghouse automatic air brake is the standard.

3. What compresses the air?

A. The air pump located on the locomotive.

PUMPS.

4. What are the different sizes of pumps in use on this road?

A. The 8-inch and 9½-inch pump.

5. Name the principal working parts of the 8 and 9½-inch pumps.

A. 9½-inch pump has main stem piston, main slide valve, differential piston and connection rod, reversing slide valve, reversing valve rod and plate in the steam end. In the air end we have the air piston, two receiving and two discharging air valves.

8-inch pump we have the main steam piston, main valve, reversing valve, reversing rod and plate, and reversing piston, five in all. The air end has the air piston, two receiving and two discharge valves.

6. Explain how a pump should be started and run on the road.

A. Slowly, to allow the condensation to escape from the steam cylinder; also to accumulate sufficient pressure in the air cylinder to form a cushion for the piston.

7. How should the air cylinder be oiled, and what kind of oil?

A. The air cylinder should be oiled with small amount of valve oil, and then through the little cup provided for that purpose, and never through air strainer, as it will gum up air valves and passages.

8. What is the maximum speed a pump should be run, and why?

A. Not over 120 single strokes per minute, or fast enough to maintain a full pressure, and allow the pump governor to stop it once in awhile.

9. Give some of the causes of a pump heating.

A. Pump running at too high rate of speed, working against too high a pressure, leaky air cylinder, packing rings broken or stuck inlet or discharge valves, insufficient lubrication.

10. If a pump runs hot, how would you proceed to cool it?

A. First reduce speed of the pump, then put small quantity of good oil in air cylinder, running pump slowly until cooled.

11. If a pump stops, how can you tell whether the trouble is in the pump or in the governor?

A. Break the joint between the governor and pump; if steam did not get by governor, would know that the pump was not getting steam and trouble was in governor; if the pump was getting steam and pump stopped, trouble would be in pump. On modern pumps there is a pet cock provided to test the governor.

12. State the common causes for the pump stopping.

A. Loose nut on the piston rod in the air cylinder, a broken reversing valve rod, one disengaged from the reversing plate, a loose reversing valve plate, bad packing ring in main valve, or reversing piston in 8-inch pump, or lack of proper oiling.

13. If the pump stopped on the road, what would you do to start it?

A. I would reduce the main reservoir pressure, then close the throttle to the pump and open it quickly to unseat the governor valve; should this not start it, I would remove the cap over the reversing valve rod and put in a little valve oil. Should it then not start, I would take off the plug in the lower cylinder head (air end) and see if the nuts were off from the air piston; this last named defect would not allow the reversing valve rod to operate the reverse valve.

GOVERNORS.

14. What stops a pump after pressures have been obtained?

A. The pump governor.

15. How many styles of governors in use on this road. Name them?

A. Two. Single and duplex pump governors.

16. Explain the working of the governor.

A. The governor is operated by air from the main reservoir. The air enters the governor under a copper diaphram, which has a spring and an adjusting screw on top of this diaphram and generally adjusted to hold a pressure of 90 to 130 pounds, depending on the type of equipment; the diaphram forms a small chamber, into which the air accumulates until the tension of the spring is overcome and the diaphram depressed slightly. Attached to the diaphram is a little valve known as the pin valve, and its duty is to allow the air in the chamber to pass into another little cylinder below, operating the piston which controls the steam valve of the governor. Should the main reservoir pressure drop slightly when the governor valve is closed the pin valve will reseat and the little relief port will let the air out that was holding the steam valve on its seat. The steam pressure acting

under the governor steam valve will open the valve and allow it to pass to the pump.

17. To what pressure is the pump governor connected?

A. To the main reservoir.

18. How can a governor be adjusted to obtain a higher or lower pressure?

A. By adjusting nut and spring. To increase pressure screw down on the nut; to decrease pressure unscrew the nut.

19. What is the object of the relief port in the governor, and why should it be kept clean?

A. It is to relieve the pressure on top of the governor piston after pin valve has been seated, and should be kept clean to have the pump start promptly.

20. If the pin valve leaks, what effect will it have on the pump?

A. Pump will be slow in starting, and if it were so great that the relief port could not relieve it would cause the pump to stop.

21. What is the steam drip for?

A. Steam drip is provided to relieve any steam that leaks by the governor piston rod which is attached to governor steam valve.

22. What is the effect if the steam drip gets clogged or frozen up?

A. Steam at nearly boiler pressure will form under the governor piston and the pump will run air pressure up to boiler pressure or very nearly.

MAIN RESERVOIR.

23. Where does the air go to from the pump?

A. To the main reservoir.

24. What is the object of the main reservoir?

A. To store a large volume of air used in releasing and recharging the brakes.

25. On some locomotives the main reservoirs are extra large. Why is this?

A. Because we need a larger volume of air to release brakes and a recharge on long trains.

26. Why does water accumulate in the main reservoir, and how often should it be drained?

A. The main reservoir should be drained at the end of every trip; all air passes here before going to the brake pipe, resulting in a condensation and water formation here.

27. How much pressure should be carried in the main reservoir with single governor? How much with duplex governor with low speed brake?

A. 90 lbs. single governor; duplex governor 110.

28. What is excess pressure?

A. Difference between train line and main reservoir pressures.

29. What is excess pressure used for?

A. To release brakes, recharge train line and auxiliaries.

30. How much excess pressure do we carry.

A. 20 lbs.

31. Where does main reservoir pressure begin, and where does it end?

A. It begins at the discharge valve of the pump and ends at the rotary valve on lap position and at the feed valve on running position.

32. Which hand on the gauge indicates the main reservoir pressure?

A. Red hand, 90 lbs.

33. Which hand indicates the brake pipe pressure, and what should it be?

A. Black hand, 70 lbs.

ENGINEER'S BRAKE VALVE.

34. What is the standard type of engineer's brake valve used in road service on this system?

A. 1892 model equalizing and discharge valve and E. T. equipment.

35. On switching engines with and without the straight air equipment?

A. The Westinghouse combination automatic and straight air brake.

36. Why is the 92 model valve called an equalizing discharge valve?

A. Because it mechanically measures out the amount of air, no matter how long the train line may be.

37. Name the different positions of the 92 model brake valve handle.

A. Full release, running lap, service application and emergency.

38. What divides the main reservoir pressure from the brake pipe pressure when valve is in running position?

A. The feed valve.

39. When in lap position?

A. The rotary valve.

40. On which side of the rotary valve is main reservoir pressure?

A. Top side.

41. Explain the effect of a cut rotary valve or seat.

A. I would not have any excess pressure. When brakes were applied they would gradually release owing to the main reservoir pressure leaking into the brake pipe through the rotary valve and forcing triple pistons to release position.

42. How would you test for a leaky rotary valve?

A. Make a 20-pound reduction in brake pipe and place valve on lap, cut out the brake valve and watch black hand; if it raises in pressure it is a leaky rotary

valve. Another way, put valve on lap and start pump, cut out brake valve and watch black hand.

43. In what position of the brake valve is there a direct communication between main reservoir and brake pipe?

A. Full release.

44. What is the duty of the small reservoir connected to the brake valve?

A. To increase the volume of chamber D pressure.

45. If the pipe leading to the equalizing reservoir should leak, what would be the effect?

A. When brakes are applied they would go on too hard, and as long as the handle is left in lap position you will also have a blow from train line exhaust.

46. When the equalizing piston fails to seat, how can you tell if it is a leakage of equalizing reservoir pressure or dirt on seat of the valve?

A. Cut out the brake valve, put the brake valve in full release; should this stop the leak it would be due to leakage in equalizing reservoir pipe. Should it continue it is evident that dirt was on the seat of the valve. I would then try to blow it off by placing the handle in full release and then back to emergency several times.

47. If the pipe connection between the brake valve and small reservoir got broken, what would you do?

A. I would plug up the pipe, also plug up train

line exhaust in the brake valve and proceed, using the brake valve in emergency position carefully.

48. In making a service application of the brakes, how is the air exhausted from the brake pipe?

A. Where we reduce chamber D pressure above the equalizing piston, the train line pressure on the under side forces the piston up and allows the train line pressure to escape through the exhaust valve.

49. What pressure does the black hand show directly?

A. Chamber D pressure.

50. How does the brake pipe pressure escape when handle is placed in emergency position?

A. Direct to atmosphere through the direct application and supply port and the direct application and exhaust port.

51. If the equalizing discharge piston becomes gummed or corroded, what would be the result?

A. It may result in emergency application on a short train. Too great a reduction would have to be made in a service application and set brakes too hard on any train.

52. What will be the result of leaving the handle of the brake valve in full release position too long and then moving it to running position?

A. Brake pipe pressure would become overcharged and when moved to running position the brake pipe

leakage would apply the brakes, as the feed valve will not take care of any pressure above its adjustment.

53. How is the brake pipe pressure regulated with the 92 model valve?

A. By a feed valve.

54. What attention should the feed valve receive?

A. It should be kept clean and properly adjusted.

55. How will the presence of dirt and gum affect it?

A. Will not regulate the pressures and makes a sluggish feed valve.

56. Explain use of warning port.

A. It is to call the attention of engineer to position of brake valve handle.

57. What pressure escapes at this port?

A. Main reservoir.

58. If it gets plugged up, does it affect the operation of the brake valve?

A. No.

59. Where is the air stored on the engine?

A. In the main reservoir, auxiliary reservoir, brake pipe and equalizing reservoir.

60. Where stored on each car?

A. In the auxiliary reservoir and brake pipe.

TRIPLE VALVES AND AUXILIARY RESERVOIRS.

61. Where does the auxiliary reservoir directly obtain its air?

A. From the triple valve.

62. About how long does it take to charge an auxiliary reservoir, and why?

A. About 70 seconds on account of the feed groove in triple piston bushing being so small.

63. About how large is the port from the brake pipe to the auxiliary reservoir in the triple valve?

A. 3.32 of an inch, or size of lead in pencil.

64. Why is this port made so small?

A. So that all auxiliaries will charge alike throughout the train.

65. What is the duty of the triple valve?

A. To charge the auxiliaries, apply and release the brakes.

66. How many forms of triple valve are there in use on this road?

A. Two. The plain and quick acting triple valves.

67. Difference between them.

A. The quick acting triple has a set of valves called the emergency valve, which the plain has not.

68. Name the working parts of the plain triple valve.

A. The triple piston, slide and graduating valve, graduating stem and spring.

69. Name the working parts of the quick action triple valve.

A. The triple piston, slide and graduating valve, emergency piston and emergency or rubber seated valve, train line check valve, graduating stem and spring.

70. What are the duties of the triple piston?

A. To charge auxiliary, apply and release brakes, move the slide and graduating valve.

71. What pressures govern its movement?

A. The brake pipe and auxiliary reservoir pressures.

72. How do these pressures compare with brakes fully charged?

A. Equal.

73. Name the pressure on the plain side of the triple piston.

A. Brake pipe pressure.

74. What are the duties of the slide valve?

A. Open and close communication between the auxiliary and brake cylinder, and brake cylinder and atmosphere.

75. What are the duties of the graduating valve?

A. To graduate the amount of air from auxiliary to brake cylinder.

76. What is the principle that applies and releases the brakes?

A. The difference of pressures of air on either side of triple piston.

77. Explain where the air comes from that enters the brake cylinder in service application.

A. Air comes from auxiliary reservoir to the brake cylinder through the graduating valve.

78. In emergency application, with each kind of triple valve?

A. With the quick acting triple it comes from auxiliary reservoir and brake pipe. With the plain it comes from the auxiliary only.

79. How do you cut out a plain triple valve? And quick action?

A. Cut out plain triple with a cut-out cock in side of triple. Quick action is cut out by cut-out cock in crossover pipe located between auxiliary and triple.

80. What position must the triple piston be in to charge an auxiliary reservoir?

A. Full release.

81. Do plain and quick action triple valves operate alike with service application?

A. Yes.

82. With plain triple valves, emergency application, will the brakes apply any harder?

A. No.

83. Will they apply any quicker?

A. Yes.

84. With the quick action triple valve, an emergency application made, will the brakes apply any quicker and harder than with a service application?

A. Yes, they will apply quicker and harder.

85. How much harder, and where did the extra pressure come from?

A. 10 lbs. harder. The extra pressure comes from brake pipe.

86. By reducing the brake pipe pressure five pounds, how many pounds of air will go from the auxiliary reservoir to the brake cylinders?

A. 5 lbs. or a trifle more.

87. What prevents more from going?

A. The graduating valve reseating.

88. When the brakes are fully applied, how do the pressures in the auxiliary reservoir and brake cylinder compare?

A. They are equal.

89. With 8-inch piston travel, how much is necessary to reduce brake pipe pressure to accomplish this?

A. 20 lbs. to 25 lbs.

90. What will be the effect of a leak in the emergency valve, triple piston in release position?

A. There will be a bad leak in brake pipe pressure; it would set brakes should the pump not supply the leak; it would also cause a constant blow at the triple exhaust.

91. What effect will a broken graduating spring have on a long train? On a short train?

A. Broken graduating spring on long train would have no effect, as the brake pipe reduction would be so gradual. On short train it would make a kicker or cause all brakes to be applied in emergency.

92. What is the effect of a broken carrying pin, brakes applied in service application?

A. Broken carrying pin, service application of brakes, would cause all brakes to apply in emergency.

93. If one quick action triple goes to emergency, will it affect the other brakes in the train?

A. It will, because when the pressure is suddenly reduced in the brake pipe it causes all others to be reduced in like manner.

94. How would you locate the defective triple?

A. On short passenger trains there is generally men that can be stationed at each car and watch each brake; as it applies on long passenger or freight, turn the angle cock behind 5 or 8 cars and watch them, and so on through the train until it was located.

95. When applying the brakes in service applica-

tion, can you detect if any of the brakes go to quick action? Explain.

A. Yes. If brakes are working O. K. the brake pipe exhaust at brake valve will be gradual and according to length of the train, but if they go to the emergency the brake pipe exhaust at the brake valve will be short and quick, regardless of the length of the train.

96. If triple piston packing is worn and brakes are released in running position, what is liable to result?

A. Brakes would stick, owing to the fact you could not build up the brake pipe pressure sufficient to force the triple piston to release position.

CYLINDERS AND PISTON TRAVEL.

97. What is meant by piston travel?

A. The distance the piston travels in brake cylinder.

98. What is the standard piston travel for tenders and cars?

A. Eight inches.

99. If the piston travel is more than 8 inches what is the effect?

A. It reduces the braking power.

100. What is the shortest piston travel to be had on tenders and cars with safety, and why?

A. Five inches; 4 inches would give too great a

braking power and skid wheels, and less than 4 inches the piston might not get by the leakage groove in the brake cylinder.

101. What is the leakage groove in the brake cylinder for?

A. To allow any air that might leak by the slide valve to escape.

102. What causes the piston to return to release position when the pressure has been released from the cylinder?

A. A coil spring which is around piston rod causes piston to return to the cylinder.

103. How is the piston travel adjusted on tenders and cars?

A. By dead levers.

104. How is the piston travel adjusted on engines?

A. By adjusting screws and cam nuts.

105. Has the piston travel anything to do with pressure obtained in the brake cylinder?

A. It has everything to do with pressure obtained in brake cylinder.

106. Should a brake be cut out before adjusting piston travel, and why?

A. It should. To prevent personal injury.

107. What should be done after repairs were completed, such as adjusting piston travel, and why?

A. It should be cut in and brakes tried, to know that the brake is working with the proper adjustment.

PRESSURE RETAINING VALVES.

108. Where are the pressure retaining valves generally located?

A. At the top of the car near brake wheel, or in some convenient place where trainmen can get at it.

109. To what are they connected?

A. To exhaust port of the triple valve.

110. What is the use of the pressure retaining valve?

A. To retain a certain pressure in the brake cylinder when brakes are released, which retards speed of train while recharging brake pipe and auxiliary reservoirs.

111. How much pressure is retained?

A. 15 lbs.

112. Name the defects which cause the retaining valve to be inoperative.

A. Dirt on seat of the valve or the pipe broken off.

113. Which end of the train should they be used on, and why?

A. Head end of train, to keep train bunched when releasing on long trains.

114. Retainers in use, recharge, will the brakes apply any harder on second application?

A. Yes.

115. Give reasons?

A. Because we already have 15 lbs. in brake cylinder to build on.

116. Who should be authority for number used?

A. The engineer.

TRAIN AIR SIGNAL.

117. What is the use of the train air signal?

A. It serves as a communication between engine and train.

118. What pressure should be carried in the signal line?

A. 45 lbs.

119. Where is this supply taken from?

A. The main reservoir.

120. Name the valves used to operate the air signal on the engine.

A. The reducing valves and signal valve.

121. Duty of reducing valve.

A. It reduces main reservoir pressure to signal pressure and is adjusted at 45 lbs.

122. How can the reducing valve be cut out?

A. By a small plug cock in side of reducing valve.

123. How is it adjusted?

A. By an adjusting screw and spring.

124. Duty of signal valve and how operated?

A. It's duty is to blow the whistle. The signal valve is charged to equal pressures above and below

the rubber diaphram, to which is attached the signal valve. A quick reduction in the air signal pipe causes a reduction on top of rubber diaphram, allowing the pressure in under to be the greater, forcing diaphram up, lifting valve from its seat and allowing the air to pass to the whistle, causing it to blow. The valve is reseated again by pressure from the main reservoir.

125. If the whistle blows when releasing brakes what does it signify?

A. Trouble is with the pressure reducing valve in allowing too high a pressure to build up in the signal pipe, which feeds back into the main reservoir. When release is made this feeding back into main reservoir causes a reduction in signal pipe pressure and the whistle to blow.

126. What effect will a leak have in the signal line?

A. It will cause the whistle to blow frequently.

127. Where would you look for the trouble if the signal pipe does not charge?

A. At the reducing valve.

128. If the signal pipe is charged and whistle will not blow, where would you look for the trouble?

A. In the whistle itself the bell is too high or too low, or the stem is bent and bell would not come over the bowl; also look at the signal valve.

129. Should the several parts of the signal equipment be kept clean, and what is the result if neglected?

A. It should be kept clean, otherwise it would not give correct signal.

130. Is any change in the signal equipment necessary when coupling two or more locomotives together?

A. No.

STRAIGHT AIR BRAKE.

131. What additional parts are needed on engine and tender to have straight air brake in connection with the automatic brake?

A. A straight air brake valve and a double seated check valve, a reducing valve, a brake cylinder safety valve and the necessary piping.

132. What is the duty of the double check valve, and how does it operate?

A. The double check valve is located on both engine and tender in the pipe leading from triple valve to the brake cylinder. Its duty is to stop the flow of air to the straight air brake valve during an automatic application, and to stop the flow of air to the triple valve during a straight air application.

133. What pressure should the reducing valve used with this brake be set at?

A. 45 lbs.

134. What pressure should the safety valves be set at?

A. 53 lbs.

135. How do you operate the straight air brake?

A. The pressure is taken from the main reservoir. Supplying the automatic brake, it passes through the reducing valve, which is set at 45 lbs.; then through the straight air brake valve to the double seated check valve, then to the brake cylinders.

136. What are the safety valves for?

A. In case the reducing valve gets out of order, it will prevent brake cylinder pressure getting too high.

137. Can the straight air and automatic be used separate from each other?

A. Yes. The double seated check valve allows this.

TRAIN HANDLING.

138. Should an engineer know the condition of the brakes before leaving the engine house?

A. Yes.

139. Should brakes be tested before leaving a terminal?

A. Yes. To know how many brakes he has and that they can be operated from engine.

140. At what other time must the brakes be tested?

A. When any change of train line is made.

141. What is meant by a running test?

A. Applying brakes before shutting off steam, making not less than 5 pounds to 7 pounds reduction.

142. At what points of the road should the running test be made?

A. At points where it is considered essential to know the condition of the brake; say, before descending grades, before approaching stations; also when train is under way after leaving stations where cars have been picked up or set off.

143. What is meant by terminal test of brakes? Explain details, giving inspectors' duties also.

A. A terminal test of the brake is the charging of the entire train, making a full service application and its inspection.

The inspectors' duties are to couple the engine to the train and air hose; after the system is charged he should whistle the brake on from the first car; on passenger trains he should start at the engine and inspect each brake. At the rear end of the train he should whistle for release and make an inspection on his way back to the engine to see that all have released properly, and report to the engineer.

On freight trains he should see that all air hose in the train are coupled up; he should be at the engine to have the brakes put on and start at the engine, going to the rear car, noting the condition of each brake, including the engine. When at the end of the train he should give the release signal and return to the

engine, watching for leaks in the train pipe and noting the condition of the brakes after the release.

144. Why is a terminal test necessary?

A. To know the condition of brakes before starting, and to know the brakes can be applied from the engine.

145. What do you wait for after coupling to train before testing the brakes?

A. Wait until train pipe and main reservoir pressures are all charged up.

146. At what pressure should brake pipe and auxiliaries be charged before making terminal tests?

A. At 70 lbs. with low speed brake and 110 with high speed brake.

147. To charge train quickly, in what position should the brake valve handle be placed?

A. Place brake valve handle in full release.

148. How do you know when auxiliaries are fully charged?

A. When the pump stops running or slows down to its minimum speed.

149. How much reduction should be made when testing brakes?

A. A 25 lb. reduction is necessary to get full braking power.

150. Why would not a five or ten pound reduction be sufficient?

A. It might not give the proper piston travel, or

it may not be sufficient to force the pistons by the leakage grooves.

151. Is it necessary to have 70 lbs. pressure to obtain full braking power?

A. Yes, it is quite necessary.

152. After applying brakes and black hand continues to fall, what does it indicate?

A. This would indicate a brake pipe leak.

153. What is a leak in the brake pipe liable to do if the pump does not maintain the pressure?

A. It will reduce the braking power, as you cannot get the proper reservoir pressure, and should the leak be greater than the pump could supply it would cause an entire loss of the air and no brake.

154. How would you test for brake pipe leaks?

A. Wait until train pipe is charged up and make a 5 to 7 pound reduction; place brake valve handle on lap. Should the black hand fall it would indicate a brake pipe leak.

155. If in applying the brakes you had made a five pound reduction, and the brake pipe exhaust should suddenly close, black hand falling to about 55 pounds, what would it indicate, and what would you do on a freight train?

A. This indicates a kicker, or one triple valve going into emergency. On a freight train would cut it out after locating it.

156. How would you handle a train having a defect of this kind?

A. As it is dangerous, cut it out to avoid further trouble.

157. As a rule, how much is it necessary to reduce brake pipe pressure to force pistons by leakage grooves?

A. About 5 to 7 pounds.

158. In making stops with passenger trains, ten cars or less, when should the brakes be released, and why?

A. Release just before coming to a stop to avoid shocks.

159. With longer passenger train, over ten cars, when should the brakes be released, and why?

A. After coming to a stop to avoid breaking in two and other serious shocks.

160. When should the brakes be released on freight trains?

A. After train has been brought to a stop.

161. How many applications should be used to stop a passenger train?

A. Two applications.

162. How should brake valve handle be handled between applications?

A. Carried on running position.

163. How many applications should be used to stop freight trains, and why?

A. One. Because if more is used it is liable to result in broken draw bars and other serious damage to the train.

164. What is an application of the brake?

A. An application of the brake is from the time it is applied until released.

165. Explain why the amount of air from the brake pipe exhaust varies with different lengths of trains?

A. With the long train we have a larger volume of air than with a shorter, and it takes longer for the air to flow through exhaust port of brake valve.

166. If in case you fail to get the proper exhaust from the brake pipe, what would you do?

A. If in motion stop at once and have train examined. See if the train has all of its cars cut in; if all right, examine for a hose with a loose lining.

167. If the air whistle should blow twice in leaving a station, where would you place the brake valve handle?

A. In service application and never in emergency.

168. How would you make a stop for water with a passenger train?

A. With two applications of the brake, the second as light as possible, stopping with brake applied.

169. With a freight train?

A. Make one application; after stopping cut off the engine and proceed to the water plug.

170. If it becomes necessary to again apply the brakes immediately after releasing, do you understand that there is a higher pressure in the brake pipe which must first be exhausted before the action of the brakes can be secured? Explain why.

A. Yes. Because the air charges slowly through triple to auxiliary reservoir, and when we release, for instance, place brake valve handle in full release position we charge train pipe to 70 pounds and the auxiliary pressure being, say, 45 pounds, should we want to apply brake it will be necessary to reduce brake pipe pressure below 45 pounds before any air will pass pass to the brake cylinder.

171. Before applying brakes on a freight train what should you wait for to avoid shocks to the train?

A. Wait until slack is all run in (or bunched).

172. Should brakes be released at a slow rate of speed with a freight train, and why?

A. No. As it will result in broken draw bars and other serious damage.

173. Suppose you were stopping for a signal with a freight train and when nearly stopped, signal should show clear, what would you guard against?

A. Guard against breaking the train in two.

174. Why is it dangerous to repeatedly apply and

release the brakes without giving time for auxiliaries to recharge?

A. This will result in a great loss in braking power, if not entire loss of air.

175. In double-heading, which engine should do the braking?

A. The leading engine.

176. What would you do if you were on the second engine, so that the head engine could do the braking?

A. Cut out brake valve with old equipment.

177. If on second engine and man on leading engine was disregarding signals and rules, what would you do?

A. Cut in my brake and put it in emergency position.

178. Is it essential that the engineer should look at the gauge often that the pressures may not leak off without his knowledge?

A. Yes; very essential.

179. What determines the length of time the handle should be left in release position in releasing brakes?

A. The length of train and the amount of air required to recharge the auxiliary reservoirs.

180. What places should be picked out to recharge on grades?

A. Curves should be picked out to release at, be-

cause the train will bind more and reduce its motion.

181. When recharging, how long should brake valve handle be left in release position?

A. Until the brake pipe is charged, or all brakes released.

182. Should engine be reversed with driver brakes applied, and why?

A. No. Because it will slide the drivers and little or no braking power will result.

183. How would you proceed in case of bursted hose?

A. Place brake valve on lap position and wait until train stops.

184. How can you help trainmen locate it?

A. By moving from lap to full release for short intervals.

185. When brakes go on suddenly without action of the engineer, what are the causes and what should be done?

A. Generally a bursted hose or someone pulling conductor's valve. Place brake on lap and wait until train stops.

186. Do you understand that the emergency application should not be used in making stops for water, or others, only in case of emergency?

A. Yes.

187. What objections are there in using the brake in emergency?

A. It causes dirt and water scales, etc., to flow through the brake valve and will cause brake valve to move hard, if not cutting its seat.

188. If the back-up hose is to be used, in what position should the brake handle be carried and how long left there?

A. Should be placed on lap, and left there until train has come to a stop.

HIGH SPEED BRAKE AND TRUCK BRAKE.

189. What is the difference between the low speed and the high speed brake?

A. We carry higher main reservoir and brake pipe pressure, and we also have the truck brake.

190. What additional parts are there on the engine with the high speed brake also on the cars?

A. The duplex governor, adjustable feed valve, the special triple valve for lead truck and the high speed reducing valve, and an extra auxiliary reservoir.

191. What pressure is carried in the main reservoir and brake pipe with the high speed brake?

A. Main reservoir 130 pounds; in brake pipe, 110.

192. Explain in a general way the operation of the high speed reducing valve, at what pressure are they adjusted?

A. The high speed reducing valve essentials consists of an air piston acting in a cylinder operated by air from the brake cylinder during applications. On one side of this air piston is a spring and set screw which generally has a tension of 60 lbs., acting directly on the piston, the air from the brake cylinder tends to compress this spring as it has direct access to it. On the opposite side of this spring is a slide valve which is connected to the piston, which has a triangular shaped port cut in it which is moved by the air piston in any application, resulting in a brake cylinder pressure of 60 lbs. or over, causing the spring to compress. This little valve moves on a face and is held there by the air pressure and a spring; this face has a little port about the length of the triangular port in the slide valve and about 1/8-inch in width. During an ordinary service application of the brake, should 60 or more pounds of air accumulate in the brake cylinder, the piston will compress the spring and cause the slide valve to move down slightly until the lower or wider part of the triangular port lets the air out to the atmosphere via the release port, and does so quickly. Now in the emergency application of the brake, a sudden pressure is thrown into the brake cylinder, and so quickly that it runs the brake cylinder pressure up to 85 or 88 lbs., and acts so

suddenly that it forces the piston down its full length, pulling the smaller end of the triangular port to register with the release port in the valve face, making the flow much less and gradual until it is brought to 60 or a little below.

The object of the high speed reducing valve is to increase the friction between the brake shoe and wheel which is reduced during high speeds, and must be reduced with the speed of the train, since the adhesion of the wheel to the rail is about the same at all speeds.

193. What is the function of the high speed reducing valve?

A. To automatically control the brake cylinder pressure according to application made.

194. How much pressure develops in the bráke cylinder with high speed brake with standard piston travel, emergency application?

A. From 85 to 88 pounds.

195. If a car is not equipped with a high speed reducing valve what can be done so this car can be used in a high speed train.

A. Take out the oil plug in the brake cylinder and put in a safety valve.

196. If a train with a high speed brake should pick up a car not equipped with same, what would engineman do?

A. Cut down to low speed. (See 195.)

197. How does the engineman change from high to low speed brake?

A. By turning the feed valve to the left until it strikes the stop provided for this purpose and reduce the brake pipe pressure below the feed valve adjustment.

198. What are the advantages with the high speed brake?

A. Quicker stops and better control of the train in every respect.

199. How many full service applications can be made without recharging and have left as much pressure as is used with the low speed brake?

A. Two applications.

200. How many triple valves used on an engine with the truck brake and how many auxiliary reservoirs?

A. One special triple valve and two auxiliary reservoirs.

201. How do you cut out a truck brake?

A. By a cut-out cock attached to pipe leading from triple valve to the brake cylinder.

E. T. EQUIPMENT (5).

202. What parts do the E. T. Equipment do away with on engine and tender?

A. All triple valves, auxiliary reservoirs, double check valves, and high speed reducing valves.

203. What takes the place of these parts?

A. The distributing valve.

204. When charged, where is the pressure stored on the engine?

A. In the main reservoir, equalizing reservoir and pressure chamber of the distributing valve.

205. What is the duty of the distributing valve?

A. To apply and release the brake on engine and tender; also to maintain a brake cylinder pressure of 45 pounds against brake cylinder leakage.

206. What is the use of the safety valve connected with the distributing valve and what pressure is it adjusted at?

A. To not allow more than 53 pounds of air in the brake cylinder, and adjusted at 53 pounds.

207. How many pistons are there in the disdistributing valve? Name them.

A. Two. The application and the equalizing pistons.

208. How many chambers has the distributing valve reservoir? Name them.

A. Two. Application and the pressure chambers.

209. How many brake valves with the E. T. Equipment? Name them.

A. Two. The automatic and straight air valves.

210. How is the brake pipe pressure regulated?

A. By the feed valve.

211. Name positions of both brake valves.

A. The automatic, full release, running, holding, lap, service, and emergency; straight air valve, No. 5 equipment; full release, running, lap and service; No. 6, full release, running, lap, quick service and slow service.

212. What is the use of the holding position?

A. To hold the engine and tender brake on and release the train brakes and to hold up the slack.

213. In what position must both brake valve handles be carried when not in use?

A. In running position.

214. What position does automatic brake valve have to be in to release engine and tender brake?

A. In running position.

215. How can distributing valve be cut out, also brake cylinders?

A. By a cut-out cock leading to the driver brake cylinders, and another cut-out cock leading to the tender brake cylinders. The distributing valve may be cut out by a cut-out cock between distributing valve and main reservoir.

216. What chamber does air have to be put in, to apply brake on engine and tender?

A. Air must be put in the application chamber.

217. Where does this air come from with service application and with emergency application?

A. In a service application air comes from the main reservoir. With the emergency application from the main reservoir and equalizing reservoirs.

218. How does this admit air to the brake cylinders?

A. In service application we make a reduction in train pipe and also the pipe leading to the equalizing piston of the distributing valve, which moves the equalizing parts to service position, changing application chamber and then this pressure moves the application piston which then moves the application valve, allowing air to flow to the brake cylinders.

219. Where does the air come from that enters the brake cylinders?

A. Main reservoir.

220. When should the independent brake valve be used?

A. When the engine is running light; also when we want to release the engine and tender brake and hold train brakes on; when on the road or heavy grades, to relieve tires of excessive heat.

221. What pressure do we get in the brake cylinders on engine and tender brakes applied with independent brake valve?

A. 45 pounds.

222. What regulates the pressure to be used with the independent brake valve, and what should it be?

A. Reducing valve, which reduces air from main reservoir to the brake cylinder; it should be 45 pounds.

223. What is the difference between the cut-out cock in this equipment and old equipment in the brake pipe under the brake valve?

A. With the old equipments we have an ordinary plug cock, with this equipment we have a double cut-out cock which cuts out the train pipe and at the same time cuts in the double-heading pipe. When the brake valve is cut out, it gives the engineer on the second engine control of the brake on his engine only. The double-heading pipe acts as a distributing valve release pipe when double heading.

224. With E. T. Equipment can you release train brakes and hold engine and tender brakes on? How?

A. Yes. By placing automatic brake valve handle in full release and then returning it to holding position of the brake valve.

225. Can you release engine and tender brake and hold on train brakes? How?

A. Yes. By releasing with the independent valve, which allows the air to flow out of application chamber.

226. What should be done on rear engine when double heading with E. T. Equipment?

A. Cut out the brake valve and put brake valve handle on lap position.

227. If you were on second locomotive and driving wheels were skidding, what would you do?

A. I should place independent brake valve in release position.

228. Would that interfere with the train brakes?

A. No.

229. Can you re-apply engine and tender brakes, and how?

A. Yes. By placing independent brake valve on service position, and returning it to running position.

230. In what position must the independent valve then be placed so brakes can be released with automatic brake valve on the head locomotive?

A. It should be placed on running position.

231. What regulates signal line pressure with this equipment?

A. The same reducing valve that controls the air supplied to independent brake valve.

232. Can brakes be released at a slow rate of speed with this equipment in freight service, and how?

A. Yes. By placing the automatic brake valve in full release and returning it to holding position.

233. What is the object of cut-out cock in discharge pipe from main reservoir?

A. Its purpose is to hold the main reservoir air when we wish to work on the various parts of the equipment; if it were not for this cut-out cock it

would be necessary to drain all air off and stop the pump.

234. How do we change from low-speed brake to high-speed with the E. T. Equipment?

A. By turning the feed valve regulating handle to high-speed position.

235. What would cause engine and tender brake to release after making a service application and returning brake valve to lap position, and what would you examine?

A. Leaks in application chamber or application cylinder; examine all piping leading to application chamber.

236. What should the piston travel be with the E. T. Equipment?

A. Piston travel should be sufficient to give a good brake shoe clearance.

237. Does piston travel have anything to do with pressure developed in the brake cylinders and brake holding, providing pistons do not bottom in cylinder, and does brake cylinder leakage affect the holding of the brake, and why?

A. No, as the reducing valve takes care of the brake cylinder pressure, and the distributing valve takes care of all brake cylinder leakage by moving the application piston from lap to application position accordingly as the reductions in pressure on each side of the application piston are made.

238. What should you guard against in descending grades with the E. T. Equipment?

A. Heating of tires and skidding of wheels.

239. Do you understand that no excuse will be accepted for over-heating of tires and skidding of wheels with the E. T. Equipment?

A. Yes.

Why should the brake cylinder piston travel be as short as possible?

A. It is a waste of air and also causes slack to run into the engine when releasing brakes.

NO. 6 E. T. EQUIPMENT.

154. What are the parts composing the dead engine fixtures?

A. A cut-out cock, combined strainer and check valve with a choke fitting and piped from the train pipe to the main reservoir pipe.

155. What is the purpose of the "Dead Engine" feature of the E. T. Equipment?

A. To allow an engine without air to be operated by an engine that has air, or to get breaking power on a dead engine.

156 How is this done?

A. In order to get an application of the brake with a dead engine and this equipment it is necessary to

have air in the main reservoir. By cutting in the combined strainer and check valve, air will flow from the brake pipe to the main reservoir of the dead engine.

157. When is this apparatus used?

A. When the air pump is out of commission.

158. Should the cut-out cock always be closed except when the compressor is inoperative?

A. It should.

159. Describe the flow of air through the combined strainer and check valve.

A. When the cut-out cock is opened, the air from the train pipe flows through the strainer, and after passing this it lifts a small check valve which is held on its seat by a spring, then through the small choke fitting to the main reservoir.

164. When the dead-engine feature is used, in what position should the automatic and independent brake valve handles be carried?

A. In running position.

165. What should be the position of the double heading cock?

A. It should be cut out.

BROKEN PIPES.

265. What would be the result if the brake pipe branch to the distributing valve broke off?

A. It would set the brakes on engine and train.

266. What should be done if this happens on the road?

A. Plug the pipe on the end next to the train pipe and use the independent brake valve for the locomotive braking.

267. Would it be possible to use the locomotive brake in this case?

A. Yes, using the independent brake valve for this purpose.

268. What would be the result if any of the pipe connections between the distributing valve and the brake cylinders broke off?

A. It would cause a large loss of air from the main reservoir and may release other brakes on the engine and tender.

269. What should be done in a case of this kind?

A. I would cut out the cylinders if there was a cock to cut them out, if not, I would plug the broken pipe. Should it be near the distributing valve I would cut out the distributing valve supply pipe.

270. What would be the effect if the supply pipe to the distributing valve broke off?

A. It would cause the brakes to set, all the main reservoir pressure would escape, and the engine would be without any brake.

271. What should be done?

A. I would try to replace the pipe by using a piece

of brake cylinder pipe. If I could not do this I would close the cut-out cock or plug the pipe.

272. What would be the effect if the application cylinder pipe to the distributing valve broke off?

A. I could not get an application of the engine brake.

273. What should be done?

A. I would plug up the pipe next to the distributing valve and use the automatic brake valve to handle the engine with.

274. With this opening plugged and the brake automatically applied, can it be released with the independent brake valve?

A. No, the automatic brake valve will have to be on running position to release the engine brake.

282. With the lower pipe to the excess pressure head plugged, or with both pipes plugged, what would control the compressor?

A. The maximum head will control the pressure.

283. What should be done in the event of the pipe connection to the maximum pressure head breaking off?

A. I would plug the pipe.

284. What would control the compressor?

A. The excess head.

285. In such a case, would the excess pressure head control the compressor at all times?

A. In service, lap and emergency positions it does not control the main reservoir pressure.

286. What would happen if the handle were left in lap, service or emergency positions or it became necessary to close the main reservoir cut-out cock for any length of time?

A. It would run the main reservoir pressure up to nearly boiler pressure.

287. What precaution should be taken with the governor out of commission in this way?

A. The pump should be shut off.

288. What should be done if the equalizing reservoir pipe breaks off?

A. Do the same as for the old 92 model valve, namely, plug the broken pipe, also the train pipe exhaust and use the emergency position carefully to obtain a service application.

289. Why should extreme care be used when operating the brake valve in this manner?

A. To avoid emergency applications or quick action and the forward brakes on the train releasing when going back to lap.

290. What should be done if the pipe between the feed valve and automatic brake valve got broken?

A. Screw back on the feed valve. This will stop any flow of air out at that end of the broken pipe, next plug the end near the automatic brake valve, use full release position to charge the train pipe and carry

it there while running. Of course you will have no excess pressure, but you will have a brake, nevertheless.

CHAPTER II.

Combustion and Firing.

1. What is the cause of all motion?

A. Heat is the cause of all motion. To explain clearly heat in fuel applied to the steam boiler and converted into motion through a steam engine. Heat is the cause of motion in the electric plant operated by water. The water vapor raised from the ocean by the sun's rays and dropped inland as rain. The course of the water on its way back to the ocean is harnessed up through water wheels, causing motion and electric generation of power, and other methods beyond the scope of this book.

2. What is heat unit?

A. Heat unit represents 777 foot pounds of work or a 1-pound body falling 777 feet would impart an equivalent to one unit of heat. The heat units contained in 1 pound of the average coal should be from 12,000 to 13,500, hence it can be clearly seen the energy stored up in coal.

3. What is heating surface?

A. Heating surface is that portion of the boiler

subjected to the products of combustion which transmits the heat to the water, namely, firebox sheets, flues and superheater elements in superheater locomotives.

4. What is the chief element of combustion in soft coal.

A. Carbon.

5. What per cent. of Bituminous coal is carbon?

A. Eighty-five per cent. is considered a very good average.

6. What must be the temperature of the fire to burn the gas?

A. From 1800 to 2000 degrees F.

7. Explain the principle compositions of Bituminus coal.

A. Carbon, oxygen, sulphur and ash and the principal other constituents are found, but these are the principals.

8. Does the fire burn more briskly in cold weather than warm?

A. Yes, remarkably so in very cold weather.

10. How is the evaporation power or the quantity of heat in coal measured?

A. By the number of heat units contained in it. If all the heat in coal applied to a locomotive could be converted into work, the result would reduce the consumption of fuel over 60 per cent.

11. Why is heavy firing wasteful?

A. Heavy firing tends to reduce the temperature of the firebox, which also makes dense, black smoke, owing to the inability to get the proper amount of air in to completely burn the smoke. The larger portion of the smoke passes off through the stack and is wasted.

12. How many cubic feet of air is necessary to burn 1 pound of coal completely?

A. About 247 1-2 cubic feet are necessary to give a complete combustion; that is, to burn the coal to carbon dioxide.

13. How much of the energy of fuel is consumed in combustion and explain?

A. In perfect combustion we can realize about 13,000 to 15,000 heat units per pound of coal, the same being burned to carbon dioxide, but, however, suppose we cannot get the proper amount of air and oxygen to combine with the fuel we get carbon monoxide, giving 4,500 heat units per pound of coal.

14. How much air is necessary to burn one scoop-full of coal?

A. There are about 18 pounds of coal to the scoop. Using a No. 2, therefore, it would require 5,400 cubic feet of air to be passed into the fire box to burn one completely, basing the amount of air to burn one pound of coal at 300 cubic feet or 24 pounds.

15. When is there also a great waste of fuel other than incomplete combustion?

A. The coal or carbon deposited into the ash pan represents a loss from 20 to 30 per cent. in an unburned state. Sparks thrown from the stack represents from 2 to 10 per cent. unburned carbon.

16. What per cent of oxygen is contained in air?

A. One-fifth of the volume of air is oxygen.

17. Does the flame from the fire enter the tube?

A. Not more than 5 or 6 inches from the firebox end.

18. Why does a front end when opened, for instance when the netting is plugged, catch afire sometimes when the door is opened?

A. At the time the front end is opened there is a compound known as carbonic oxide which takes fire when it is exposed to the air.

19. Mention some important features relative to combustion in locomotive boilers.

A. It is claimed that one pound of steam discharged from the exhaust nozzle will displace 2 1-2 pounds of smoke box gases. The amount of steam discharged from a cylinder is equal to about .49 or 1-2 of a pound for each exhaust; of course, there will be four exhausts for each revolution of the driving wheels, and the engine cncerned will be made up of cylinders 20 x 30, and worked at about 25 per cent. cut off. Therefore, the amount of air which will be drawn through the fire of normal thickness and free from clinker would be about 5 pounds. The amount of

oxygen would be equal to 1 pound. Since it requires about 18 to 20 pounds of air to burn 1 pound of coal it will show why heavy firing is a detriment to fuel economy.

20. What is the draft pressure when the engine is running and how measured?

A. The draft pressure is from 2 to 6 inches in water when the engine is running, depending on the position of the lever. Draught is measured by a U-shaped tube connected to the smoke box and opened at one end, the partial vacuum pulls the water up and is placed in front of a rule.

21. What pressure is indicated by the steam gauge? What is meant by atmospheric pressure?

A. The pressure per square inch on each square inch inside of the boiler. Atmospheric pressure is that as registered by the barometer. At sea level it is 14.7 pounds.

22. What is the source of power in a steam locomotive?

A. Heat applied to water, producing steam.

23. About what quantity of water should be evaporated in a locomotive boiler to the pound of coal?

A. From 5 to 9 pounds of water per pound of coal.

24. What is steam and how is it generated?

A. An elastic gasous vapor generated by the application of heat to water, is invisible under pressure.

25. At what temperature does water boil?

A. At sea level 212 degrees F.

26. Is air necessary for combustion?

A. Yes.

27. Why is it necessary to provide for combustion a supply of air through the fuel in the furnace?

A. We must have oxygen to make combustion. One-fifth of the air about is oxygen.

28. How can you prove that it is necessary to supply air to the firebox for combustion?

A. When the fire gets clinkered the rate of combustion is less. When the netting gets plugged there is a suspension of the rate of combustion.

29. What is the effect upon combustion if too little air is supplied through the fire? If too much air is supplied?

A. The rate of combustion is less and poor steaming engine results. Holes in the fire and variation of steam pressures.

30. What effect on combustion has the closing and opening of dampers?

A. Reduces the rate of combustion when closed; increased when open.

31. How is draft created through the fire?

A. By the exhaust steam passing through the stack.

32. In what condition, therefore, should the fire

be, in order that the best results may be obtained from the combustion of coal?

A. Clean and free from clinkers, ashes, etc.

33. What effect is produced by opening the fire door when the engine is being worked?

A. Reduced temperature in the firebox, leaky flues are the results.

34. What effect has the fire upon a scoopful of coal when it is placed in the firebox?

A. Distills the gases from the coal, also heats it up to its ignition point.

35. In what condition should the fire be to consume these gases?

A. A good bright fire.

36. How can the fire be maintained in this condition?

A. By careful firing and the proper working of the engine and proper feeding of the boiler.

37. What is black smoke? Is it combustible?

A. Hydrocarbon. It is combustible.

38. Can the firing be done more intelligently if the water level is observed closely?

A. Yes; the injector feed can be regulated to absorb the heat, otherwise at times it may be wasted by the engine blowing off.

39. What advantage is it to the fireman to know the grades of the road and the location of the stations?

A. He can regulate his fire and give attention to

the abatement of black smoke and maintain a better steam pressure.

40. How should the fire and water be managed in starting from a terminal or other station?

A. After the reverse lever is hooked up the firebox door should be opened and the fire worked as is necessary, using the hook or shovel for the purpose. The injector should be put an after the fire has been hooked over and the steam pressure raised to its working point.

1. What causes the drumming noise often heard when an engine is idle? How can the noise be stopped?

A. The explosion of carbon and oxygen, caused by holes in the fire, or a thin fire; open the firebox door a little; put the blower on slightly.

2. Does the condition of the grates influence free steaming?

A. Yes.

3. What effect do deflector-plate and smoke-box appliances exert upon the steaming of an engine?

A. They offer resistance to the flow of the gases. The deflector-plate serves as a means of cleaning the front end.

4. What effect on coal consumption has the practice of smokeless firing?

A. It reduces the fuel consumption.

5. What makes regulating of air admission to the fire important?

A. We must have oxygen; about 1-5 of the air is oxygen.

6. What effect upon the boiler has steady firing?

A. Keeps a constant temperature; prolongs its life; no flue failures.

7. What is the origin of all mechanical power?

A. Heat.

8. What is a fair per cent. average of carbon found in bituminous coal? About how many heat units result from one pound of good bituminous coal being burned under the most favorable circumstances?

A. From 65 to 85 per cent. From 11,000 to 15,000 heat units.

9. What are the principal things that chemistry teaches in connection with combustion? What elements perform the principal functions in a burning fire?

A. That it is a chemical action. In coal, carbon, oxygen and hydrogen.

10. Is there any form of combustion besides burning?

A. There is—oxidization.

11. What do you know about oxygen? Is the presence of oxygen essential to life?

A. Oxygen is about 1-5 of the air; 2 atoms of this gas combined with carbon gives us carbon-dioxide and 14,500 heat units per pound. It is very essential.

12. What is the principal element in all fuels?

A. Carbon.

13. What weight of air forms the atmosphere? What gases compose the atmosphere?

A. At sea level it is 14.7. Nitrogen, oxygen, hydrogen, argon and pure air contains about .04% carbon dioxide.

14. What heat units are produced when one pound of hydrogen gas combines with its full share of oxygen? When one pound of solid carbon combines with oxygen to form carbon dioxide how many heat units result? When one pound of solid carbon receives only sufficient oxygen to create carbon monoxide how many heat units result? What makes a conspicuous difference between carbon monoxide and carbon dioxide?

A. 62,032—14,500—4,500; the amount of oxygen supplied to the fire.

15. How many pounds of coal per mile does the engine you fire burn when hauling an ordinary train? How much coal must at that rate be burned per hour on each foot of grate area?

A. Pacific types, 22 x 28 cylinders, 130 to 139.

Pacific, 54 square feet, 74 pounds per hour per square foot.

16. Tell something about the relative efficiency of combustion to carbon monoxide and combustion to carbon dioxide for steam making.

A. Carbon monoxide has 4,500 British Thermal Heat units. Carbon dioxide has 14,500.

17. What are common sources of waste in the operation of a locomotive? Who is in the best position to stop wasteful practices?

A. Blowing off of safety valves. Pumping the engine too full of water. No co-operation between engineer and fireman. Pounding the engine across the flats or down hill. The engine crew.

CHAPTER III.

Locomotive Draft Appliances.

41. How is the diameter of stacks determined?

A. Some roads have a standard size of 15 7/8 for all sizes of cylinders 18 inches and over. Other roads use the formula of 6/7 of the cylinder diameter on a tapered stack. This would apply to the larger end. Apply this formula to an 18 inch to 20 inch cylinder. Example 6/7x20= $\frac{120}{7}$ =17 1-7 or a 17 inch stack for an 18 inch cylinder = $\frac{6}{7}$x18 = $\frac{108}{7}$ 15 3/7 or 15 1/2 stack.

42. What should be the objective point in the drafting of a locomotive?

A. To have the engine steam freely without choking the cylinders. What should be the objective point in regard to the flow of gases through the front end?

43. To keep the resistance to their passage down to a minimum. What is the chief resistor?

A. The baffel plate and netting.

44. When smoke comes out on the side of the stack what is the cause?

A. The petticoat pipe does not line up with the stack.

45. With the M. M. front end, what should the baffel plate opening be?

A. With 19 inch to 22 inch cylinders the plate should stand about 12 inch to 13 inch opening, and its angle relative to that of the deck should be from 105 to 110 degrees. Experience shows that this arrangement cleans the front end best, and is a mutual point between excessive gas resistance and front end filling due to the excessive height.

46. What can be said in favor of bridged tips using a single exhaust nozzle?

A. By using a bridge it is sometimes possible to get two or three inches more area of the nozzle. Experience has shown this and the steaming and running of the engine increased.

47. Using the M. M. front end and extension ad-

justable stack, what is a desired height for the location of the extension stack or petticoat pipe?

A. From 7 1/2 inches to 8 inches above the tip set securely and centrally located.

48. How would you tell the area of a tip before bridged and after?

A. Multiply the diameter of the tip by itself and this result by .7854, the result will be the area in square inches. Generally a bridge is square iron from 3/8 to 1/2 inches; for example, 5 inch tip 5x5 = 25x .7854 = 19.63 square inches from the sum; supposing we are using ½ inch bridge, 5 inch tip, rectangle is the product of length by width, therefore 1/2x5 = 2 1/2 or 2.5; subtracting this from 19.63 we have 17.13 square inches after compensating the area taken out for the bridge.

It is a good plan to know just what the areas of the tips are before and after bridging it being the objective, not to change the number of square inches in the original tip before changing. The following are some of the areas in square inches for the various sizes of nozzles: 4 1-4 inches area 14.186 sq. ins., 4 3-8 inches area 15.033 sq. ins., 4 1-2 inches area 15.904 sq. in., 4 5-8 inches area 16.8 sq. ins., 4 3-4 inches area 17.721 sq. ins., 4 7-8 inches area 18.665 sq. ins., 5 inch area 19.635 sq. ins., 5 1-8 inches area 20.629 sq. ins., 5 1-4 inches area 21.648 sq. ins., 5 3-8 inches area 22.691 sq. ins., 5 1-2 inches area 23.758 sq. ins., 5 5-8 inches

area 24.85 sq. ins., 5 3-4 inches area 25.967 sq. ins., 5 7-8 inches area 27.109 sq. ins., 6 inch area 28.274 sq. ins.

49. When the diaphram plate is set at 13 inches how is it the fire does not burn mostly under the door?

A. Setting the petticoat pipe at 7 1-2 inches or 8 inches over comes the strong draft through the upper flues.

50. Name some essentials in the drafting of an engine.

A. The importance of keeping the resistance due to draft appliances down to the least possible amount.

There are a few things that should be borne in mind. In order to have a perfect draft the engine should have an opening and stack diameter equal to the combined area of the flues; of course this cannot be accomplished on a locomotive. The inside area of a single 2 inch flue at the end is 2 3-4 square inches; very nearly take an 18x24 inch engine with 256 flues the combined area would be equal to 704 square inches; with this type of an engine 407 square inches is about the maximum that can be run with good results so far as cleaning the front end properly is concerned. In order to show the great benefits derived by running the diaphram as high as possible, take for instance a small passenger engine 18x24 cylinders, 60 inch boiler at the first ring and baffel plate 10 to 12 inches from the bottom of the smoke arch at the cen-

ter of the plate is the best that practice will allow. Let us assume that the engine has run some time at 10 inches, the total square inches at the point is 307.9, now if the engine will run the plate at 11 inches and accomplish the same results you have gained in draft area the sum of 47 square inches, and a resultant reduction of resistance to the passage of the products of combustion. It might be said that the baffel plate in this position may cause the fire to burn on the back section greater, and a more severe draft through the top flues. This can be easily overcome with another advantage, the lowering of the petticoat pipe to a position of not less than 7 1/2 inches from the tip will equalize the draft and bring about much better conditions.

Practice has shown that the longer the stack the more smoke box gases will be displaced if the stack is filled by the exhaust steam at the lowest possible point. The reason advanced for this to say the greater length the steam fills the stack the more partial vacuum will be formed. Of course the friction of the gases nearer the top of the stack will be greater than it would be had the steam not filled the stack half way up, but experience shows that to fill at the bottom makes the engine steam better.

These rules are applied to the extension stack apparatus only. There are several schemes which are resorted to in order to obtain the greatest area open-

ing under the diaphram plate; for instance, take the engine stated being at 10 inches from the bottom of the arch to center of the baffel plate; now if we can raise this to 11 inches we have gained 47 1-2 square inches, while at this position the engine may not clean the front end, the application of two wings projecting below the baffel plate 3 inches below and 3 inches wide on each side, the total derived by raising the plate is 47 1-2 inches, and the wings use up 3x3, which is 9 inches on each side or 18 inches in all; by doing this we get 29 square inches more than at the original position. Practice shows this arrangement to be very good for two reasons. The wings make the engine draw a little lighter on the flues all over the tube sheet, and lighter still on the sides, since an engine tends to burn the fire more at the sides it is a means of regulating this.

Another reason in favor of this scheme is the throwing the sparks diagonally helps to break them up into smaller elements and pass them through the netting without plugging. The petticoat pipe, located at a point 7 1-2 inches over the tip will assure cleaning the top of the scabing or deck.

No pains should be spared in locating the defects in the draft appliances. A convenient means for the locating of leaky steam pipes or exhaust bases, which has been used quite successfully, consists of blocking the nozzle on top with an oak board and leather

gasket, applying the gasket to the nozzle the board on top of this, and then using a small jack make the joint tight; it is often convenient to place a small piece of 2x4 across the petticoat pipe to jack against. After making the tip tight by this means close the throttle valve, disconnect one cylinder cock and attach a hose and place the reverse lever in the corner so the valve will open the steam port. For instance, suppose the engine is set on top quarter, placing the lever in the forward corner will open the front steam port to the exhaust port. Placing the hose on the back cylinder cock connection water pressure can be applied and will fill up the steam passages, pipes and pass over the top of the valve, down through the exhaust cavity and up to the top of the exhaust base through the hole on top of valve. After the pressure has been applied, open the throttle valve, which will let out any accumulation of air that may be contained in the pipes or passages, but be sure and close securely again. It will be necessary to see that the wheels are securely blocked to prevent the engine moving under the water pressure. This method is more economical on water and can be prepared in shorter time than to fill the entire boiler; it is also advantageous when the engine is wanted at short notice, as it does not reduce the temperature of the water in the boiler, therefore aids the quick firing up again. Other methods which are used to determine any leakage of the steam pipes

is as follows: Apply about 60 pounds of steam to the cylinder cock in the same manner in which the water was applied for some time, then turning the steam off apply the water again, this will show up expansion or contraction, and the reaction on the steam pipes can be noted accurately. After the steam pipes are ground in it is advisable to apply about 30 to 60 lbs. of steam in this way in order to have the pipes expand, and while in this state to allow a further tightening of the flange bolts. On single exhaust bases it is a good plan to block down the exhaust passages at the flange, or in other words use a blind gasket in conjunction with a template of the base; this will give chance to get a wrench on the nuts instead of using a set and hammer for the purpose.

51. How are leaky steam joints caused?

A. By unequal expansion and contraction; for instance, take the number of times the steam is entirely off, and number of times the engine is fired up; in the best cases it is at least eight times from the time the engine comes from the shop until it is returned for general repairs. A great many times steam pipes are not tested at that when in the shop. The amount a steam pipe will expand can be told by multiplying its length by the co-efficient of expansion. Per foot, for example, co-efficient of expansion is equal to .001144, that is the metal per lineal foot will expand .001144 eleven hundred and forty-four millionths of

an inch for each lineal foot between temperatures of 32 F. and 212 F, so some idea can be had of the action on these pipes from this cause.

The writer had an experience with leaky steam pipes as follows: An engine about to be turned out from the shop was tested before it was set on its driving wheels and found to be tight; after the test it was raised up by a crane and set on its drivers the following day, went into service and caused a delay to the train on account of low steam. The engine was taken back into the shop and the forward flange on the flue sheet found to be leaking badly. Notwithstanding the fact that it was thoroughly tested with hot water before going on the crane, the only reason that could be advanced for this was since the engine was jacked up at the ends of the frame about 34 feet distant from each other the deflection or the moment of initia was enough to cause a slight deflection in the center of the boiler, and since the saddle was rigid on the forward beam of the dry pipe was allowed to move slightly and caused a new seat and leaky joint resulted. The absence of the pedestal braces on the bottom of the driving box jaws increased the moment as it was inecessary to take them off in order to have the engine come down on the driving boxes.

CHAPTER IV.

Locomotive Boilers and Appurtenances.

92. What are the principal parts of a locomotive boiler?

A. Fire box, tubes, barrel, smoke box and dome.

93. What steam pressures are engines that you are familiar with allowed to carry? Does that denote total pressure or pressure per square inch?

A. 150, 160, 180, 190, 200 and 210 pounds per square inch pressure per square inch.

94. Name the sheets in the fire box.

A. Tube, side, crown, door sheets. Other sheets are outside throat back and roof sheets.

95. How is the strength of iron and steel affected by being heated to red heat?

A. Its strength is reduced.

96. Since heat has this effect upon steel, how is it that the fire box and sheets which are quite thin, and are subjected to a high temperature, and the steam pressure 200 pounds pressure per square inch can bear such pressure without being either torn or deformed?

A. The water conducts the heat through the sheets keeping them at the same temperature nearly as that of the water.

97. What are crown-sheet stays and what duty do they perform? What are flues and what are their use?

A. Radial stays are generally used; they perform the same duty as the stay bolt staying the crown sheet. Flues are for heating surface. The heat of the products of combustion is absorbed by the water surrounding them.

98. How are the surfaces of the boiler exposed to the heat from the fire prevented from becoming overheated?

A. They are covered with water.

99. How can you tell the depth of water on the crown sheet?

A. The top or highest point in the crown sheet should be three inches below the lowest reading of the water glass.

100. What is an engineman's principal duty in regard to the care of the boiler?

A. He should be careful in pumping and use the blow off cock before starting out on the trip in bad water districts. To see that the boiler carries the proper steam pressure and that the safety valves are in good working order. Also assist the fireman in keeping an even pressure by co-operating with him.

101. What means have you of ascertaining the steam pressure in the boiler?

A. By a steam gauge.

102. What effect does extreme variation in steam pressure have on the boiler?

A. Broken staybolts, cracked sheets, leaky flues and mud rings.

103. Should the water glass be relied upon entirely to show the correct water level in a boiler?

A. It should not always.

104. In the design of a locomotive boiler what is desired in maintaining a highly efficient shell?

A. By reducing the number of boiler joints or seams to a minimum.

105. Why are boiler seams or joints a detriment to the boiler?

A. Because the efficiency of the joint or the relative strength to that of the solid sheet varies from 82 per cent. to 94 per cent. in modern locomotive boilers.

106. What is the efficiency of a double butt strap joint used on modern locomotive boilers?

A. It is about 82 per cent. to 85 per cent.

107. How is the safe load of a boiler joint determined?

A. Multiply the thickness of the sheet by the tensile strength and then by 85 per cent. and divide by 5.

Assume a ¾ sheet 56,000 pounds the tensile strength of the sheet thus ¾x56,000=42,000, this multiplied by .85 per cent.=35,700, and this divided

by 5 the factor of safety=7140 pounds safe load on the seam.

108. What is desired in designing water legs of the fire box?

A. To get a proper circulation at this point.

109. What have tests shown on some water legs when the locomotive has been worked to its hardest or fullest capacity?

A. It has been shown that there is almost an absence of water at this point, owing to the rapid evaporation.

110. What can be done to remedy this?

A. A wider water leg would assist materially.

111. What are the dimensions of some of the modern Pacific type locomotives at the fire box?

A. The inside width of the water legs are 4½ inches, at the mud ring 5½ at top on the back, 6½ at top on the sides and 6 inches at top and on the throat.

112. How does the pressure act on the tube sheet?

A. It tends to bulge or round it out.

113. What supports the tube sheet?

A. Tubes, throat stays and stay bolts. The front sheet is supported by tubes, gusset, crow-foot, or angle braces.

114. How do you tell the strength of boiler plate?

A. Multiply the thickness by its tenstile strength For example: a 3-4-inch plate 60,000 pounds tenstile strength would be 45,000 pounds.

115. How would you know the tenstile strength of a boiler plate?

A. The tenstile strength is plainly stamped on each sheet.

116. How can you tell the thickness a boiler shell should have?

A. Take the diameter of the boiler multiplied by the steam pressure and divide by two times the load on the joint. The load on the joint can be found by dividing the tenstile strength of the plate by 5 and multiplying by 85 per cent. Thus a sheet of 55,000 tenstile strength $\frac{55000}{5}$=11,000x85%=9,350 pounds.

Suppose the boiler has a 72-inch ring (largest sheet) and carries 200 pounds of steam, we have 200x72=144,000 divided by 9,350x2=18,700, we have $\frac{144000}{18700}$=.72, nearly which would call for a ¾ sheet, which is (.75) expressed in a decimal.

117. How is the safe working pressure of a firebox computed?

A. Multiply the thickness of the sheet by itself and then by 286,720 and divide by the steam pressure. Thus, say, a ½ sheet, we have ½×½=¼ or a decimal of .25; this multiplied by 286,720= 71,670 and say the boiler carries 200 pounds of steam, we then have $\frac{71670}{200}$=358. This is the strain

this size of sheet will carry safely; of course, the strain on the flat surfaces must be taken care of and stay bolts must be used to find the number of stay bolts required. The strain of a stay bolt should not be more than 5,500 pounds per inch of cross sectional area. Say the box has 10,800 square inches and the steam pressure is 200 and using 1-inch stay bolt then the total pressure is 10,800x 200=2,160,000 and this dividend by 5,500 will give the number of bolts required, which is 393. The pitch of the bolt would be the steam pressure divided into 5,500 and the square root taken from this. Thus $\frac{5500}{200}=27.5$ and the square root is 5.2; therefore, the pitch would be 5 inches.

118. How would you tell the strength of boiler plate by the rivet hole?

A. Multiply the thickness of the plate by its tensile strength and by the pitch of the rivet.

119. How would you determine the relative efficiency of the solid plate to the plate after the rivet hole had been drilled?

A. Multiply the thickness by the diameter and tensile strength and subtract the distance in pitch which was drilled away and dividing the first by the second will give the efficiency. For example: say 3 1-2 inches between centers of rivet holes, using a 1-inch rivet, from the center of each hole would take in 2 1-2 inches, or the diameter of one

1-inch rivet subtracted from the original distance; therefore taking the tenstile strength at 56,000 pounds and a 3-4-inch sheet, we would have the original strength as follows: $\frac{3}{4}$x56,000=42,000x 3=126,000; therefore 126,000 pounds would be the tensile strength of the sheet before drilling. After drilling we would have $\frac{3}{4}$x56,000=2$\frac{1}{2}$=105,000. Then dividing greater by less we have $\frac{105000}{126000}$ or $\frac{105}{126}$ =83%.

120. What is the rule used by boiler makers in approximating the diameter of a rivet and its pitch?

A. Multiply the thickness of the boiler plate by two for the diameter of the rivet; for the pitch of the rivet multiply by 2 1-2.

121. What rule is used in determining the pitch of stay bolts in locomotive boilers?

A. The pitch of stay bolts in locomotive boilers is 4 inches. There is, however, a rule which is taken as follows: multiply the diameter of the stay bolt by 5,500, divide it by the steam pressure and extract the square root of the quoient. For instance, a 1-inch stay bolt, 200 pounds of steam $\frac{5500}{200}$ $\sqrt{27.5}$=5 inches nearly.

122. What pitch is given to locomotive boilers generally?

A. Four inches.

123. How would you find the pressure a crown sheet would stand?

A. Assume the boiler to be new and the crown sheet to be ⅝-inch plate, multiply the length by width times steam pressure, and then by 12, dividing this product by 2000, which will give the pressure in tons and then by 2.66.

124. What is the surface on the forward tube sheet above the tubes called?

A. The segment to be braced.

125. To know the number of braces required on a head of this kind what is necessary?

A. Its area must be found.

126. Why is this necessary?

A. Because we must know the surface sustained by each brace in square inches.

127. What rule should apply for the number of braces required.

A. The strain on the stays on the head of the locomotive boiler should not be subjected to more than 7,000 to 8,000 pounds to each inch in cross-sectional area.

128. Is the tube sheet as strong as any other sheet in the boiler?

A. No.

129. Why is it not as strong?

A. Because its strength is reduced by the tube holes.

130. How can you tell the relative strength to that of the solid plate?

A. The efficiency or relative strength of the tube sheet is found by taking the pitch of the tube holes and subtracting the diameter of one of the tube holes and dividing the result by pitch of the tube holes in inches. Thus a 2-inch tube hole and the pitch or distance between the tubes at the centers is 2 5-8 inches, then we have $\frac{2\frac{5}{8}-2}{2\frac{5}{8}}=25$ per cent. nearly. Should the tube sheet be of 55,000 pounds tenstile strength the ligament would be 55,000x.25%=13,750 pounds per square inch on a 5-8 sheet the strength of ligament would be 8,593 pounds.

131. What is the allowable shearing strain on rivets?

A. Iron rivets in single shear, 38,000 pounds; iron rivets in double shear, 70,000 pounds; steel rivets in single shear, 42,000 pounds; steel rivets in double shear, 78,000 pounds.

132. How should the factor of safety be applied to a boiler which has been in service some time?

A. Its factor of safety should be increased .1 for each year after ten years of service. For a boiler in service after this time it should have a factor of safety of 5 1-2 instead of 4 1-2, which is the case with a new boiler.

133. How can you prove that the pressure on a tube sheet tends to round it out?

A. I have seen tube sheets rounded out when the tubes were in poor condition and their holding power lessened by being rolled excessively and the beadings cut off by so doing and the tube sheets bulged out 1-4 inch from the center point in the sheet.

134. What is the space of tubes on modern locomotives?

A. About 5-8 inches.

135. What is meant by pitch of the tubes and stay bolts?

A. The distance from the center of one tube or stay bolt to the center of the next adjacent one.

136. What distinct improvement is the flexible stay bolt over the rigid stay bolt?

A. The ability of the stay bolt to allow expansion and contraction of fire box sheets without breakage.

137. What has been shown by experience with the flexible stay bolt?

A. Engines have been run from shop to shop without any renewals.

138. What do you infer by saying that engines are running from shop to shop without any renewals?

A. I mean that the engines make their assigned

mileage, which ranges from 55,000 to 90,000 miles, according to the type without any breakage of stay bolts or renewals of the flexible bolts.

139. What is the greatest mileage on record for flexible stay bolts without renewals?

A. An Atlantic type engine on the New York Central made 243,000 miles without any renewals.

140. What can you give as causes of flue failures?

A. There are several causes of flue failures, namely, First: a variable temperature and pressure, this being caused by a poor steaming engine or poor firing. Second: poor management upon part of the engine crew. For instance: pumping the boiler excessively when steam is shut off. Third: improper care of the grates, allowing the forward portion to fill up with ashes and causing uneven temperatures in the firebox. Fourth: carrying the door open widely while the locomotive is shut off and using the blower too hard. Fifth: improper care at the ash pit. Blower used too strong, causing the flue sheet to contract and dumping the forward section of the fire, allowing large volumes of cold air to strike the flue sheets and flues causing an unequal expansion. Sixth: improper care of engines in the engine house, filling the boiler clear up, running steam pressure down with very little fire in the firebox.

141. How can you prove that poor firing or a poor steaming engine will cause flue failures?

A. We know that heat causes expansion and that heat and pressure go together so far as saturated steam is concerned. That is temperature and pressure go up and down together. We also know that expansion and contraction in the locomotive boiler pulls or pushes the tube through the sheet, making it contract and to leak.

142. Can you give further proof that a tube is pulled through the sheet during expansion and contraction?

A. Yes. After flues have leaked severely they will be found loose in the tube sheet and must be expanded before the engine can go into service again.

143. How can you prove that poor management on part of the engineer in supplying water to the boiler will cause leaky flues?

A. It has been demonstrated in practice that an engine running down grade with the injector on will cause leaky flues, due to the fact that large volumes of relatively cold water are being put into the boiler while the fire is at a lower temperature than when the locomotive was working. The course of water circulation in the boiler and its gravity causes this cold water to pass to the lower tubes, resulting in an unequal expansion

from the fact that the upper flues are hotter, due to the condition of the water and the lower flues are cooler due to the injection of so large a volume of water at a decreased temperature in the boiler.

144. Why is it the lower flues leak more than the upper ones?

A. The water is always cooler here due to the circulation path, causing a wider range of expansion and contraction on these particular tubes.

145. What rule is sometimes used for the amount of heating surface in locomotive boilers?

A. The following is an approximate rule: Take 400 times the contents of one cylinder in cubic feet for the heating surface in square feet. For an example, a 20-inch cylinder and a 30-inch stroke, and the area of a 20-inch cylinder is 314.16 square inches, and its stroke is 30 inches. Then the contents will be 314.16x30, which is 9,424.4, add 10 per cent. of 9,424.4 for clearance volume, we have 10,369. Clearance is the space between the valve when the port is closed and the piston on the dead center, this sum divided by 1728 and multiplied by 400 will give the cubic feet, which would be equal to 6 nearly. Multiplying this by 400 would be equal to 2,400 square feet. This, however, is a little lower than that is used on a road I have in

mind, but is due to the fact to allowing a small percentage of clearance volume of 10 per cent.

146. Define direct and indirect heating surface.

A. Direct heating surface is that portion of the boiler in contact with the fire. Indirect heating surface is that not in direct contact with the fire. For instance, in the first case firebox sheets, in the second case the tubes or flues.

147. What is the relative value of direct and indirect heating surface ?

A. Under the rapid rate of evaporation in locomotive boilers of today, it has been shown that 1 square foot of fire box heating surface is equal to more than 7½ feet of tube heating surface. This is one distinct advantage of the Jacobs-Shubert fire box.

148. What is the proper plan for feed water to enter the boiler.

A. On modern types of locomotives an internal feed pipe is attached to the back head of the boiler by a combined flange and check velve body. The injector delivers water through this pipe which, leads to the forward end of the boiler and deposited at a point near the forward tube sheet. There is an objection to this location advanced for the reason that when an engine is shut off, for instance when running down hill with the injector left running, large volumes of relatively cool water deposited at this point, and due to the gravity (weight) of the water at its

lower temperature relative to that of the water already in the boiler goes directly to the lower portion of the boiler, then the path of circulation carries it back near the flue sheet, causing a wide variation in temperature and a prominent cause for leaky tubes. This assertion is borne out in practice, as it is a common fact that the lower tubes leak more frequently and are subject to the hardest service of all.

149. Describe the path of circulation in a locomotive boiler.

A. Circulation path is upward through the water legs on the inside, on the inner sheets, and downward on the outside next to the outside sheets. Circulation in the barrel on top toward the front flue sheet and on the bottom towards the fire box, near the flue sheet and at the ends, through the tubes upward, in back and down in front.

150. What is the thickness of the average fire box sheets?

A. The fire box sheets should be made thin to assist in conduction of heat into the water. Side sheets on engines carrying 180 to 200 pounds of steam should have 3/8 sheets on the side and 1/2 to 5/8 tube sheets. The same being made thicker for the purpose of holding tubes. Crown sheets should be given the same thickness as side, and should be supported by 7/8 to 1 1/8 radial stays, and should be spaced to allow not over 5500 pounds per square inch of cross sectional

area of the bolt. This to be found by measuring the distance from one crown stay to the other; for instance: suppose it is 4 inches, and the area supported by the stay would be 4 inches one way and 4 inches the other, then the area sustained is 16 square inches. The steam pressure is 200 say, multiplying the 16 by 200 we have 3200 pounds. In the case of 1-inch bolt, we would have a surplus of 2300 pounds of safe pressure allowed.

151. Why is it necessary to use stay bolts on the fire box sheets, and not on the cylindrical part of the boiler.

A. All pressures tend to form a sphere, and since the cylinder part of the boiler is round, it conforms to this shape in which the steam exerts its force. This can be proven in observation and in practice. For instance: when tubes are in bad shape, tube sheets very often bulge on account of the tubes losing their staying ability.

152. How can you determine by looking at a locomotive boiler whether it is a crown bar boiler or a radial stay boiler?

A. The crown stay boiler has its dome over the fire box; the radial stay boiler has its dome ahead of the fire box.

153. How should a crack in the five box be treated?

A. A slight crack in the fire box can be patched up

with sewing plugs providing that the distance is not more than the distance between stay bolts.

154. How should a crack in the boiler be repaired?

A. The ends of the crack should be drilled and the sheat securely patched.

155. What is one distinct advantage of the wide fire box over the smaller?

A. The larger fire box has the advantage of direct heating surface, and in addition to this the large fire box provides for a slower rate of combustion resulting in economy in fuel.

156. Why does the large fire box promote a slower rate of combustion?

A. Since the fire box heating surface has a greater value over tube-heating surface it is not necessary to force the fire and the passage of the products of combustion through the tubes is slower, giving more time for the water to absorb the heat contained in them.

157. Of what material are boiler tubes made?

A. Boiler tubes are generally made of charcoal iron with a Bessemer steel and welded on.

158. What mileage is generally available on tubes of various types of engines?

A. From 35,000 to 50,000 miles is a general average with due regard to flue failures.

159. What methods are suggested to help flue failures on large engines?

A. If it were possible to have greater circulation

space and some method of distributing feed water from the injector into the boiler without centralizing it at one spot. Another suggested method is to depress the tubes slightly.

160. What is boiler scale?

A. Boiler scale is due to impurities in the water.

161. What are some of these impurities?

A. Lime, alkali, magnesia are the principal agents.

162. Will scale cause a hard steaming engine?

A. Yes, it acts as an insulator of heat.

163. Explain how scale acts as an insulator of heat.

A. It has been shown that 1/8 inch of scale will increase the fuel consumption about 7 per cent. to 10 per cent. and about 1/4-inch scale will increase the fuel consumption from about 18 per cent. to 20 per cent.

164. How can you prove this by practical experience?

A. Engines turned out of shop with new flues will point it out clearly. The locomotive will do its former amount of work with a much less fuel consumption, which is a well-known fact to all locomotive enginemen.

165. What is grooving in a locomotive boiler?

A. Grooving in a locomotive boiler is due to the action of the seam, but primarily to oxide of iron rust having formed as a thin scale. These scales keep

breaking off as the grooving deepens, due to the buckling action.

166. What is pitting in a locomotive boiler?

A. Pitting is generally found on the water line. It is generally due to the chemical action of water.

Pitting, it is claimed, is retarded by the use of charcoal; iron boiler tubes experience shows that when a tube pits there is a small scale formed at the point where the hole is started, which some makers of tubes claim to be due to a gas found by the chemical constituents of the water.

167. How may a mud-ring leak cause a groove?

A. Any external leaks in time will cause grooves, especially so at this point because there is more or less sediment passes out and its grooving effect is increased by so doing.

In some districts where water is impure, there are noted deposits of lime or other chemical elements where a leaky mud ring is let go, which tend to increase the grooving effect of the water. Oxides are also present, near a wet mud ring, which reduces the sheets on both sides, which also pits the mud ring.

168. What method is used in supporting crown sheets?

A. The radial stay method is almost universally used at present. The older engines use what is known as the crown bar and sling stay method.

169. How would you find the safe working pressure of a locomotive boiler?

A. Let us assume the boiler has ¾ sheet and its largest ring is 72 inches, the tensile strength of the material is 55,000 pounds, the relative strength of the boiler seam to that of the solid plate is 85 per cent., therefore the formula is ¾ x $\frac{55000}{1}$ =41250, which is the strength of the sheet, multiplying this by 85 per cent., the strength of the seam we have 35,062, then dividing by ½ the diameter of the shell, which is 36 inches, giving us 979, this divided by the factor of safety which is 4.5 or 4½, will give us 217 pounds, the safe working pressure.

170. Why are flues more liable to leak after the engine has been in service some time than when the engine is turned out of the shop with new flues?

A. The new flue has been rolled but once, and we will say when put in service, after being in service some time, the frequent rolling reduces the metal and subsequently its holding power.

By Kent's Mechanical Engineer's Pocket Book tests show the holding power of a 2-inch flue to be 23,700 pounds, or 2-3 of its tensile strength.

It is safe to assume in this connection that the flue in a long boiler will sag a little, and the pressure exerted by the expansion of the flue will be resisted to such an extent to depress it more in the case of the old flue, the action of changing temperature tends to

pull the flue through the sheet in the same manner and due to the reduction of metal from expanding is weakened to such an extent that its holding power is destroyed and leakage takes place.

The factor of safety of a boiler is taken as the ratio of the load that would instantly break the material over the greatest safe ordinary load.

The factor of safety is also taken to overcome defects in make up of the material.

171. What are some of the prominent makes of safety valves?

A. The Crosby, Ashcroft and the Consolidated.

172. How is the pressure adjusted on a pop safety valve?

A. By a compression screw and check nut.

173. Suppose the safety blows back too much pressure, how wuld you remedy this defect?

A. The adjusting ring would be too high. It would be necessary to lower this ring in order to decrease the steam blowed back. It must be remembered that the compression spring controls the opening of the valve and the adjusting ring the proper closing of the valve.

174. What do you mean by saying that the adjusting ring is too high?

A. It is too near the valve.

175. How is this ring adjusted?

A. On the Ashton pop there are two adjusting screws for this purpose.

176. How would you adjust the blow back?

A. I would find a position with these side screws where the valve would blow back about 5 pounds before closing.

177. How can this be done?

A. I would have a man in the cab while I was adjusting these screws give me the pressures.

178. Can you name a convenient way of setting the pop valve?

A. Yes. Suppose the engine has a new pop and blows off at 80 pounds of steam, I would—if a four-cornered head on the tension screw—turn it one complete turn and note how much this caused the pressure to rise, and if the case was 120 pounds after one turn, each turn of the screw would indicate a rise of 40 pounds per turn, or 10 pounds per side, if a square head. Then with two more complete turns the valve would be adjusted at 200 pounds, or very nearly so, which it is assumed that the boiler does carry.

179. Has this method been tried and proven a success.

A. It has several times.

180. How would you guard against any over-pressure?

A. By having a man in the cab and the steam chest

relief valves off. He could relieve the boiler pressure by opening the throttle.

181. What is the lift of a safety valve during the discharge?

A. Three and one-half-inch Crosby valve lifts about .08 of an inch.

182. At 200 pounds' pressure what will the discharge of a 3½-inch valve be?

A. The Crosby will discharge 203.4 pounds of steam per minute at 200 pounds' gauge pressure.

183. How is the safety valve size determined?

A. By the following formula: $\frac{W \times 70}{p} \times 11$ where "W" represents weight of water evaporated per second and "70" a constant and "p" the steam pressure absolute.

The flow of steam into the atmosphere in pounds per second can be found by multiplying the area of the orifice or pipe by the absolute pressure, and dividing by 70 say 2-inch relief valve nipple on a steam chest when blowing steam off the area of the nipple will be $2 \times 2 \times 7854 = 3.14$ square inches, this multiplied by 200 for example we have 628, dividing by 70, we have 8.9 pounds of steam per second.

184. Why should external leaks about the boiler be repaired at once; especially where water and steam leakage is shown?

A. The water escaping in small jets from a

seam or mud-ring may cause corrosion from the continuous removal of the oxide of iron produced by the action of the water on the iron.

185. What are some prominent causes of pitting other than those quoted herein?

A. Forge scale or iron scale which is sometimes contained on safe ended flues, small particles of coke fed through injectors on coke burning engines. Small pieces of copper ferrules left in the boiler or brass chips, any of these may cause a galvanic action and a subsequent dissolving of the iron called pitting.

186. Then pitting may be called an electro-chemical action?

A. Yes.

187. What are the parts of an injector?

A. The steam nozzle, the combining tube, delivery tube, line check valve, intermediate overflow valve, and lever operated overflow valve of the Hancock inspirator.

188. How much steam does the injector use?

A. Each gallon of water consumes about two cubic feet of steam to operate the injector. This steam, which was used to operate the injector, is only 1-6 of its original volume—after doing its work.

189. How much above the steam pressure will an injector force water?

A. About 50 per cent. higher.

190. Do all locomotive boilers make the same quality of steam?

A. No. It will be seen by experience that the wagon top boiler makes a dryer quality of steam.

191. On the larger types of engines, is the full throttle recommended with the straight boiler?

A. No. The smaller types of engines this was possible, but on larger engines, experience shows that the engine will run away from the water; by this I mean to say an engine will run with wire drawn steam (throttle not quite wide open) will hold the water steadily at a certain point of injector feed. On the other hand, when the throttle is wide open, and the lever hooked up to give the same conditions of speed and work, it will be necessary to increase the injector feed to hold the water in the same position in the boiler. By these observations it will be seen that the full throttle on the large locomotives is not practical.

192. How do you acount for the difference in performance in the foregoing question?

A. One practical reason is advanced by saying that steam travels slower through the throttle and steam pipes, giving it time to be slightly superheated. Another good reason is, the more the throttle is open, the higher the water will raise in the boiler, and during rapid evaporation is brought nearer the throttle valve, consequently small par-

ticles of water will be carried over into the cylinder. It is a well-known fact when steam rises from the surface of the water it has a tendency to carry more or less spray with it, which, once in suspension, does not rapidly settle against the current of outgoing steam, consequently passes through the cylinder and for these reasons the full throttle is not recommended.

193. How would you know when ports are covered, with Walscheart gear?

A. Have the link block in the center of the link and the engine on the quarter.

CHAPTER V.

Superheaters.

194. What is a locomotive superheater?

A. A superheater is a device consisting of several U-shaped tubes extending from the front end steam pipes back through large tubes towards the firebox. These tubes series are connected to the steam pipe header, when steam is admitted to the cylinders, it must pass back near the fire through the superheater elements before it can pass to the cylinders, absorbing the heat of the gases in route to the smoke box, thereby increasing the heat of steam from 380 to 600 degrees F.

195. Explain why a superheater is an advantage to a locomotive.

A. Since heat is the cause of all motion it is clear that in the case of a superheater the temperature being increased over 200 degrees over that of the saturated steam will point out clearly the amount of increased energy derived. In addition to this the superheater dries the moisture out of the steam, and converts it into superheated steam, making it more elastic and more economical on fuel and water. In the engine using saturated steam, as has already been shown, some of the incoming steam is condensed from warming up the cylinder walls to about the temperature of the incoming steam. When the admission of steam is cut off an expansion commences, the condensation due to the cylinder walls continues until some point during expansion, the water on the cylinder walls begins to re-evaporate at such a rate that the weight of steam at the end of the stroke is greater than at the point of cut off. In case of the superheater re-evaporation can hardly take place since condensation is materially done away with.

196. What other advantages are derived from superheated steam?

A. The increase of efficiency is from 10 per cent. to 20 per cent., the reduction of fuel consumption is about 15 to 30 per cent. It is possible to reduce boil-

er pressure on engines carrying 200 to 180 lbs., and still get better service from the engine at a 10 per cent. reduction in steam pressure. This being done also to cut down boiler troubles which is worked out quite satisfactorily. A number of roads have bored out cylinders from 2 to 3 inches more in diameter, and cutting down the steam pressure at the same time, making about the same tractive force at a lower steam pressure. Experience shows that it would be impossible to do this with a saturated steam engine, since the steam qualities of the engine is very sensitive to any cylinder diameter change.

197. Is the exhaust nozzle increased with the introduction of super-heat engines over that of a saturated steam engine of the same cylinder dimensions?

A. No. Usually it is necessary to run a nozzle of a little smaller diameter on the super-heat engine in freight service, but not always in passenger service.

198. Does the smaller nozzle choke the engine, and explain.

A. It does not choke the engine up because the steam is much less in volume, and hotter than saturated steam would be when passing through the stack, and therefore travels at higher velocity. Experience has shown that the super-heat engine will run much faster under the same conditions as the saturated steam engine on account of the relative differences in the volumes of the steam.

199. What can be said about the amount of water to be carried in the super-heat engine?

A. The water should be carried about 1½ to 2 gauges in order to keep the water out of the super-heater, and thereby reduces its efficiency.

200. How is the moisture known in saturated steam, or how does saturated steam differ from super-heated steam?

A. In the super-heated steam at 600 degrees is practically a gas, while saturated steam is composed of quite a little moisture, depending sometimes a great deal on the design of the boiler in which it is generated, the water being suspended in the steam. There is a method in telling the amount of moisture in steam known as the calorimeter. There are several types of these instruments; one of the most common type is the barrel calorimeter, consisting of a barrel with a convenient amount of water in it, into which steam is blown and its moisture tabulated from the temperature derived and accurate record of its weights kept.

201. What precaution should be used when starting a train in using super-heated steam?

A. Start very slowly in case it is necessary to take the slack. Be very careful when the lever is placed in the forward gear. The reason for this is since the engine has stood for some time, the super-heated damper is closed, and when the train is started, the energy of the steam is about that of saturated steam

until the heat can be imparted to the super-heater by an increased draft through the larger tubes in which the super-heater elements are set. An engine standing with super-heated damper shut, will impart but little heat to the super-heater, but in case of taking the slack the damper is opened, and the steam contained in the steam pipe and super-heater will at once be heated to about the regular temperature of 600 degrees, especiallly when the blower is on, and as the lever is thrown in full forward gear the effort of the engine is greatly increased, due to the energy imparted to the steam which had stood in the super-heater during the time the lever had been reversed.

In connection with the application of super-heated steam, it may be stated, the law of expansion of gases under a constant pressure is increased or decreased in volume nearly $\frac{1}{273}$ of its volume for each degree of centigrade to which it is heated or cooled.

The chief object in superheated steam is to drive as nearly as possible the expansion of a perfect gas.

To simplify the expansion or the action of a perfect gas.

Suppose the locomotive is working cutting off at ¼ of the stroke the engines cylinders are 20 x 28 steam is admitted to the cylinders at 160 pounds per square inch, up to the point of cut off we have 160 pounds of steam after cutting off and expanding to

½ stroke, which would be 14 inches, we should have 80 pounds' pressure. At ¾ stroke we should have 40, and so on.

Saturated steam locomotives do not come very close to expanding steam adabatically.

Some rates of condensation of saturated steam in locomotives' cylinders are as follows:

At quarter cut off 25%
At half stroke 14%
At two-thirds stroke 12%

The super-heater overcomes these defects.

The Locomotive Superheater Co. give us the following instructions for care and management of the superheater:

The superheater as applied to locomotives, consists of three or more horizontal rows of large boiler flues across the upper part of the boiler, each containing a superheater unit. The usual size of these flues is 5⅜ inches, or 5½ inches outside diameter, except at fire box end, where the diameter is reduced to 4½ inches by swaging. The superheater unit is a continuous tube formed of four seamless steel superheater tubes, connected by three return bends. The front end of these units are bent and clamped to the superheater header in the smoke box. The connection is made steam tight, either by a ball joint, or in a few special cases by a copper-asbestos gasket.

The steam passages in the header are so separated that the steam from the dry pipe has to pass through the superheater units on its way to the cylinders.

In operation,, part of the hot fire box gases flow through the large flues and give up some of their heat units to the large flue and surrounding water the same as in the regular boiler tubes. Other heat units are absorbed by the tubes of the superheater units. This heat in the tubes is transferred to the steam passing through them on its way from the dry pipe to the cylinder, and as a result the steam has a much higher temperature on reaching the cylinders than when it left the boiler, briefly stated it is superheated steam.

The amount or degree of superheat is the increase of the final temperature of the steam leaving the superheater over that of the steam and water in the boiler. For example, steam at 200 lbs. gauge pressure has a temperature of 387.5 deg. F. on entering the dry pipe. On leaving the superheater, suppose it has a temperature of 600 deg. F. In that case, it has been superheated in its passage through the superheater by an amount equal to the difference between 600 and 387½, i. e., 212½ deg. F. To secure the best results the quantity of heat transmitted through the superheater units should be sufficient to superheat the steam to an average temperature of 600 deg. F.

The superheater damper is used to prevent burning

of the superheater tubes when there is no steam passing through them. The front end of the large flues discharge into a chamber which is separated from the rest of the smoke box by partition plates and the automatically operated damper. This superheater damper is held open by pressure of the steam from the steam chest acting on the piston in the damper cylinder, and permits the hot gases to flow through the boiler flues. It is closed by a weight as soon as the throttle is closed, and thereby stops the flow of hot gases through the large flues.

In some instances where special service of the engine requires it, the damper cylinder has been connected to the blower pipe instead of to the steam pipe. When this arrangement is used, the damper remains open at all times except when the blower is turned on, the counterweight acting to keep the damper open.

With reference to the design and material of engine details, the following brief recommendations are made:

Cylinder oil of high grade and high flash point is recommended.

Direct lubrication of the cylinder is recommended, and all cylinders should have an oil connection leading to the center of the top of the cylinders. If the supply of oil to the valve chamber and cylinder of the engine is regular it will be found that the superheater

engine takes but little more oil than the ordinary locomotive.

Each steam chest should be supplied with oil through one pipe leading directly from the lubricator and delivering oil in the top center of the steam chest for all inside admission valves. When the relief valve is located on the steam chest in such a way as to prevent the oil being delivered at that point, it is recommended that the oil feed deliver the oil in the steam pipe, or steam passage, leading to the steam chest. The use of an oil pipe having a branch connection just above the steam chest, and delivering oil at two points in each steam chest is not recommended, as the results obtained with this form of oil distribution are not wholly satisfactory.

Relief valves having ample area are recommended for the cylinder heads front and back, and the steam chest or steam pipes should have large-sized vacuum valves.

Piston-rod and piston-valve stem extensions are recommended in order to reduce the wear of moving parts, and permit all packing rings to float free from weight of piston and valves.

Piston valve rings and bushings should be made of close-grained cylinder iron.

The regular piston rod and valve steam packing may be used. Packing rings made of a mixture of 80 per cent. lead and 20 per cent. antimony have given

satisfactory service with the highest degree of superheat.

Swabs and oil cups should be applied and maintained in good condition on piston rods and valve stems. The same oil should be used for the swabs as is used for cylinder lubrication.

HINTS.

Don't forget when switching that there is more steam between the throttle and cylinders with the superheater than with the saturated steam engine—the superheater holds some.

Don't carry water too high just because you don't hear any in the smoke stack. You might be using your superheater to boil water instead of heating steam.

Don't think because your engine steams that you are getting the full value of the superheat; your engine may not be calling for the capacity of your boiler.

Don't close your throttle entirely on road engines until you get to going quite slow; your cylinder lubrication will be much better.

Don't shake the grates violently when the engine is working hard (we know it is easier, because we

have done it, but it was wrong); it causes the tubes and superheater units to choke up more frequently.

Don't fire your coal too wet; it won't clinker so badly if reasonably dry. The more you rake the fire the more the flues will stop up. There are only two reasons why a fire should be raked: one, because too much coal is used, and the other because it is not put in the right place.

Keep after the terminal forces to clean the superheater units. Watch this a little when you have an opportunity. You are liable to find them using anything from a short flue augor to a 1½-inch pipe. They should use about a ⅜-inch pipe, long enough to go THROUGH the flues, and this should be used with a high air pressure, along with suitable hooks and scrapers to fully clean the superheater units. If it is done in this way, they will not be clean, and the money invested in the superheater is worse than wasted, because you will then have a saturated steam engine with a low-pressure boiler with decreased heating surface, impaired water circulation drafted too strong through lower flues, causing holes to come through the fire near the flue-sheet, which has a tendency to make them leak. If this is allowed you have a low pressure saturated steam engine with big cylinders, and generally nothing to put in them.

CHAPTER VI.

Locomotive Running and Management.

52. What usually is the reason for steam being wasted from the safety valve?

A. Poor management of the engine.

53. What is the estimated waste of coal for each minute the safety valve is open?

A. About 16 pounds per minute.

54. What should be done to prevent waste of steam through the safety valve?

A. Co-operation of the engineer and fireman. With economy of fuel in view.

55. What should be the condition of fire on arriving at a station where a stop is to be made?

A. The fire should be bright and the gas burned off to prevent emission of smoke.

56. How should you build up the fire when at stations in order to avoid black smoke?

A. One shovelfull at a time, have blowers on and the door on the latch.

57. What should be the condition of the fire when passing over the summit of a long grade?

A. Have the fire covered over a little so to hold the steam pressure up to prevent wide variations of steam pressures and leaky flues.

58. Is it advisable to keep the water at the proper level and how should it be supplied?

A. Yes. The water should be carried as high as consistent in order to assure working dry steam and the injector regulating valve set to keep it there.

59. Why is it that if there is a thin fire with a hole in it the steam pressure will fall at once?

A. Large volumes of air will pass through the hole, nearly four-fifths of the air being nitrogen will absorb a great deal of the heat of the fuel and thus preventing the same to be absorbed by the water in the boiler.

60. What would be the result of starting a heavy train with too thin a fire on the grates?

A. To grate a supply of air the engine will not steam well.

61. Where should the coal, as a rule, be placed in the fire box?

A. At the sides and corners.

62. Within what limits may steam pressure be allowed to vary economically, and why?

A. From 10 to 15 pounds to prevent wide variation in steam pressures and leaky flues, broken stay bolts, etc.

63. Is it advisable to raise steam pressure rapidly?

A. No it may overheat the boiler.

64. Has improper firing any tendency to cause tubes to leak? How?

A. Yes. Causes a wide variation in steam pressure and unequal expansion and contraction.

65. What would you consider abuse of a boiler?

A. Quick throtteling, improper running of the injector, pumping the engine excessively when shut off, using the blower too hard when cleaning the fire, firing up too quickly, etc.

66. How would you take care of a boiler with leaky tubes or fire box?

A. Would put a fire up over the leaky flues if I could and have the flues repaired at terminal. Sometimes bran introduced into the tank and fed into the boiler will let you get your train into the terminal.

67. When and why should you wet the coal in the tender?

A. Before starting out on the trip to prevent the fine particles of coal being drawn through the flues.

68. What are the advantages of a large grate surface?

A. A slower rate of combustion per square foot.

9. What is important in carrying water in the boiler, as to height and regularity?

A. With a constant supply of water fed to the boiler about as fast as is being used results in a more even steaming engine. The height of water in the glass should be just sufficient to insure dry steam being worked.

10. What effect does shutting off the throttle have on the water in the boiler?

A. It causes it to drop down in the glass.

11. Should the water in the boiler get to low to allow you time for examination, what would you do?

A. I would bank the fire with dirt ashes or wet coal until steam was lowered to allow examination.

12. How would you ascertain a boiler was foaming or being over-pumped?

A. Shut the throttle; should the water show in the glass solidly it would be over-pumping or priming.

13. What portions of the engine would you disconnect in a case, provided it is necessary to draw the fire?

A. If a short distance to go I would leave all rods up, also valve gear, provided I could lubricate cylinders and valves through the independent oilers. In cold weather I would disconnect steam connections to the air pump, take out saddle and cylinder cocks, drain off the lubricator, take out wash out plugs, disconnect tank feed hose, blow out the air pumps thoroughly before disconnecting.

Sometimes there is an accumulation of water in the passages to the cylinder saddle. In cases like this, if rods are left up, I would run the engine

ahead, keeping the lever in the back gear, that is, if I were to be towed into my terminal the above would force the water out of these passages into the boiler and out of the washout holes.

14. What is important to observe in setting up or adjusting wedges?

A. To see that they are not too tight and to guard against sticking.

15. How should an injector be started?

A. Should be started slowly to allow time for priming; after this should be pulled on slowly.

16. How should an injector be stopped?

A. The injector should be stopped slowly in order to prevent the boiler check slamming and injuring it.

17. Explain the essential working features of an injector?

.A Velocity of steam, combining with it water to give it mass, and the product of the two giving the force.

18. How should the different makes of injectors be converted into a heater?

A. Hancock close the overflow valve, place starting lever in priming position, open the priming valve a little; Seller's improved close overflow valve, move the starting lever to priming position.

19. How does an injector raise water to the overflow?

A. By drawing the air out of the suction pipe the pressure of the atmosphere on the water in the tank forces it up to the injector and out the overflow.

20. Why can an injector force water into a boiler against the boiler pressure?

A. Because we have the velocity of steam combined with the mass or weight of the water giving force (any force is equal to mass times); acceleration steam has speed or acceleration but no mass (weight), and the combination of the two give the force.

21. In what way would you have control of your engine with broken link hanger, in case it was not practicable to run with link blocked up?

A. Place the lever in full gear and work with a light throttle, increase lubrication on that side.

22. Should the throttle valve become disconnected inside the boiler partly open, wide open or closed, what would you do?

A. If wide open, reduce steam pressure so the engine could be handled with the lever and brake. If partially open, get into your terminal with what train you can handle. Should it become disconnected, closed and descending a grade, I would

place the lever in the back gear when near the foot of the hill and pull the throttle stem out; the air pressure may be enough to open the throttle valve. By doing it this way would let you into your terminal or to clear the main line.

Should it be disconnected after stopping you will have to be towed in. However, you might get steam enough through the lubricator steam pipes by taking out the choke plugs to get in to clear.

23. Name the leading valve gears now used on American railways.

A. The Baker-Pilliod, Walschaert and Stephenson Valve Gears.

24. What are some of the important features of the Baker-Pilliod valve gears?

A. The elimination of sliding joints, for instance: the link block, a motion nearly in a straight line. All pins and bushings nearly of a standard size, so that the valve gear may be rebushed at a comparatively short time. A quick opening of the valve, or a full port opening of 5 per cent. of the total absence of preadmission are the chief functions of this gear.

Therefore in the mid-gear, with the reverse lever in the center notch, this will be practically all the motion imparted to the valve.

The valve gear consists of the following parts:

Eccentric rod, eccentric arm, eccentric crank, combination lever, crosshead yoke, union link, combination lifter, valve rod, bell crank, reverse yoke, radius arm, reverse arm, reverse shaft.

25. How is the variable lead derived on the Walschaert valve gear?

A. By setting the eccentric arm back of the present location for constant lead, which is 90 degrees; the range of valve events are less in the back gear than with the constant lead valve gear, and the subsequent reduction of the tractive power of the engine in the back gear.

BREAKDOWNS ON THE PILLIOD VALVE GEAR.

In case of a broken eccentric crank or rod, remove rod and broken parts; replace pin to the lifter bar; then block reverse yoke and radius yoke together and proceed with lap and lead travel of the valve and leave main rod up.

In case crosshead yoke or union link should break, remove and block combination lever and proceed with port opening travel of the valve; leave the main rod up.

In case of a broken reverse yoke, radius yoke, lifter bar, eccentric arm, combination lever, bell

crank, gear valve rod or lower reverse arm, remove crosshead connection and eccentric rod, block valve with a little forward port opening; take out forward cylinder cock and increase lubrication on that side; leave the main rod up.

26. Explain the principal of how variable lead is accomplished in the Walschaert valve gear.

A. By setting eccentric crank back of the normal position, the events of the stroke are later. On the forward and back centers of this type of valve gear, the combination lever and eccentric are counter-motions at certain positions of the stroke, or in other words, the eccentric tends to move the valve to produce later lead while the combination lever tends to give constant lead by increasing and decreasing the travel of the valve on the centers. Since the eccentric and combination lever are to a certain extent dual motions (opposite to one another) it is evident that hooking up of the lever, the effect of the eccentric on the valve will be decreased, but the function of the combination lever which is constant will be increased, relatively. The eccentric, in other words, destroys the constant lead feature in full gear, but as the effect of the eccentric is less when the lever is hooked up the engine then has the variable lead feature as found in the Stephenson gear. By a close study of these positions, it will be seen how this is produced.

27. What can be said in comparison of the constant lead and variable lead valve gears from a practical experience standpoint.

A. The variable lead engine is a much better working engine, and the disadvantage of reducing the back motion by setting eccentric back, is overcome by the good results, of the resultant increases in the forward gear.

28. What are some of the most prominent causes of the Walschaert gear sounding out of square?

A. At short cut-off, worn pins and bushings in the link block radius rod, and principally in the suspension hanger, and reach rod, and its connections to the quadrant.

29. On larger types of engines does the eccentric lead or follow the main pin?

A. In a great many cases it leads the main pin.

30. What bad feature is advanced against its location ahead of the pin?

A. In running ahead the link block is above the center of the link, and in the event of a broken suspension hanger, or one of its pins working out, the radius rod would drop to the bottom of the link, and may reverse the engine on that side, since the other link block is above the link center.

31. What strain is a valve subject to in ordinary service?

A. The lowest strain that I have any record of is 250 lbs. taken at the valve stem.

32. With the Stephenson & Walschaert valve gears, what causes an engine when starting a train and hooked up a little, to sound out of square, but when speed is raised, the valves seem to square up, especially so with the light train?

A. With the Walschaert valve gear, the friction of the valve keeps the lost motion drawn up between the valve and link to a certain extent, the inertia of the ecentrcic will take up quite a little at these points at high speed. On the Stephenson gear the friction of the eccentric cams will cause the link and hanger to maintain its lowest point, taking up a great deal of its lost motion. These conditions must, of course, have valves well lubricated, kept free from water to produce these results.

34. How can you tell the difference in the outside admission and the inside admission valves by the Walschaert valve gear?

A. The valve stem will be connected to top of combination lever if the engine has outside admission valves. If the valve stem is below the radius bar connection it will have inside admission valves.

35. At what point is the eccentric located relative to the main pin?

A. The eccentric is located at 90 deg. ahead or behind the main pin, according to how the engine is set up.

36. How is it compared with the Stephenson gear eccentric location?

A. The Stephenson valve gear eccentrics are located 90 degrees minus the lap and lead of the valve.

37. What is known as the range of cut off?

A. The range of cut off is the extreme points in which the valve will cut off the steam at boiler pressure to the cylinders. On freight engines it runs from 1 or 2 per cent. when lever is in center notch to 90 per cent., when the lever is in the corner.

46. How would you center the valve on the Walschaert valve gear?

A. Set the engine on the quarter or a position where the combination lever will stand plumb, place the lever in the center and note the position of the link block in the link it should be in the center in this position the valve should stand central.

47. How would you set the valve central on the Stephenson valve gear?

A. Set the rocker arm plumb engine standing on the top or bottom quarter, reverse lever in center notch should bring this about.

48. Does lead help to start the train?

A. No, lead does not help to start the train; starting is accomplished by the opposite cylinder.

49. What does the increasing of lead do in regard to other events of the stroke?

A. The earlier the lead the same points stroke, namely admission, cut off, release and compression are earlier.

50. When a number of engines of the same class and design are assigned to a division, a great difference is noted in the running, steaming and hauling capacity. How do you account for some of this?

A. It is quite evident in practice to find this condition existing, and the writer has given considerable study to this question. The difference in these engines is started at the throttle valve to make sure of its opening, the steam throttle and dry pipes may have uneven surface on their inside, and especially in the cylinder saddle the curvatures where the most resistance is given to the flow of steam may be rough in one engine and comparatively smooth in the other. The exhaust passages may be so contracted by faulty coreing to restrict the passage of the steam through these parts. All these passages which are in a position that they cannot be readily examined. The interior of the exhaust bases show a variation in the metal used and in the single exhaust nozzle, the height of the bridge

relative to that of the length of the base materially affects the running of the engine.

The steam leaving the exhaust tip meets with some resistance in the exhaust base tip if lipped and through the petticoat pipe and stack. Stacks are invariably rough inside, resulting in greater friction to the passage of steam and the products of combustion. The steaming of the engine may be retarded by loose or leaky joints that cannot be found without the application of a hydraulic test and then it must be careful to be sure all the air is out of the ports and passages to the atmosphere when testing.

The valve motion should be closely checked to see that the port marks are accurate and eccentrics properly located.

The amount of water used by an engine depends on the quality of steam which is generated in the boiler. Experience shows that there is quite a difference in the quality of steam generated even when the boilers are of the same design.

The deposits of scale on the heating surface of one boiler may be greater than another. This, of course, would cause a variation in the amount of water converted into steam per pound of coal.

It must be remembered that the amount of water used by an engine may be due to the following defects: Running the heating surface up too high by

spacing tubes. To close this would not allow sufficient water to pass to the lower flues, resulting in damp steam, and even pinning may result.

The design of the water legs are of no little value and the same should be sloped enough to give a width at the top to allow a free circulation.

Any of these defects will result in a poor steaming engine for the reason that the heat in fuel cannot be conducted into the water at the rate it should be, due to the absence of the proper supply not being available at these points.

51. Is lead of any advantage to the engine?

A. There are several arguments for and against this important subject and the following questions came up in the Traveling Engineers' Convention in 1912:—

52. How much lead do you allow freight and switch engines? In replying to this and subsequent questions state whether you make any difference for lead in saturated steam and superheated steam engines of the same class, using the Stephenson gear and slide valves.

53. How much lead do you allow engines in passenger, freight and switch service with piston valves with the Walschaert valve gear?

54. How much lead do you give engines with slide valves and the Walschaert valve gear in the same service.

55. Have you had engines in service without lead and state size, service, etc.?

56. Have you experimented with different leads in various types of engines and kinds of service and give results?

57. Have you a standard lead for engines of different types in the same service?

To these questions the committee made the following answers:—

There are many good arguments for lead.

It is impossible to give a fixed rule for the amount of lead to be given an engine for the amount of lead given an engine in one case would not do at all in another on account of the difference in clearance volume, cut-off and other causes that would influence lead.

The only practical way to determine is by the use of the indicator, which, if correctly used, will show whether or not the engine has the proper valve setting.

The advantages of lead are as follows.—

It gives what is termed pre-admission of steam, or steam i sadmitted to the cylinder before the piston has returned to the end of the stroke, thus furnishing a cushion for the piston and reciprocating parts.

It gives a wider opening of the steam ports when steam is admitted to the cylinder before the piston boiler pressure at the beginning of the stroke and also gives an increased port opening after the crank pin

has passed the center by keeping the port open longer than it would be were there no lead.

Lead permits an earlier cut-off in the stroke and consequently longer expansion of the steam. An increase of 1-2 of an inch in lead would reduce the cut-off a total of one inch on one side of the locomotive, but it must be remembered that increasing the lead hastens every operation of the valve. During the exhaust of a locomotive the walls of the cylinder have a chance to cool to certain extent and the pre-admission of steam or lead insures the reheating of these parts at an earlier moment than would be the case without lead.

The disadvantages of lead.

When the crank pin is at or near the dead center any pressure against the piston will have no effect to turn the wheel and if the engine has lead it will actually tend to work against the engine on the other side of the locomotive, which is at its mid stroke and therefore doing all the work at that instant of moving the locomotive forward; especially is this true for locomotives used in slow service and hard pulls. This may be overcome to a certain degree by setting the valve blind in the back gear in order to help the forward gear. By doing this the lead is made almost constant for full and half stroke.

We know that when an engine is running at full speed, if we shut off and drift we notice no ill effects

from pounding; in fact, the engine sometimes runs better, due to the lack of pounding, which indicates that a cushion by steam is not necessary, as provided for by lead to arrest the motions of the reciprocating parts.

On most all locomotives with the Walschaert valve gear have constant lead for all cut-offs. This has these advantages: the clearance volume is to be filled with steam before the beginning of the stroke is the same and amount of time for filling this space with steam decreases. This shows that the amount of lead which would do for slow speed would not give the best results for high speed. Therefore, a constant lead is not desirable.

Again suppose an engine with a Walschaert valve gear and constant lead to be working with the lever in the corner and the piston nearing the end of the stroke. In this position the piston is traveling slowly while the valve is traveling fast. Due to the lead of the valve the piston has one and one-half to two inches to go yet, while a large amount of steam is admitted to the cylinder. All lost motion of the worn parts, if any, will be taken up suddenly and a pound will result. It would indicate from this fact that a negative lead would be an advantage because the steam could not be admitted to the cylinder until the piston would be in position to use it to good, actual work in turning the wheels.

With the modern engine equipped with piston valves the exhaust lap is no doubt a move in the direction of fuel economy, also water.

You can, by this method, cushion the reciprocating parts and fill the clearance space by compression and to a certain extent maintain cylinder temperature by compression.

Then when the crank passes the center let pre-admission take place, since the pressure obtained by compression will be nearly up to boiler pressure no loss should result.

The physical characteristics of the road have quite an influence on lead also.

58. Tell the difference between the slide valve blowing and the cylinder packing, and in what manner can you tell on which side your packing is blowing?

A. Cylinder packing blow will show starting the train and will be steady. The side can be determined by watching the cross head. A slide valve blow will be a squeeky or whistling noise and continuous.

59. How would you test for a blow in the valve of a piston valve engine?

A. Set the engine on top quarter, open throttle, put lever in center, open the cylinder cocks and see if steam escapes. If it does, the valve will be blowing on that side.

60. What would you do if you had broken a spring or hanger on a standard overhung engine and had cramped the reach rod at short cut-off?

A. I would remove pin at the reverse arm and block one link where the engine would start the train on any grade and slack off on the counter balance spring and proceed; that is, for a short distance to go. If any great distance, would treat this break down as given in question 140. (B. & M.)

A question is sometimes asked, Why does an engine take more steam when the lever is dropped nearer the corner and explain?

When the lever is dropped nearer the corner the top of the link is brought nearer the link block pin, giving the valve a greater travel and making all events of the stroke later. When the engine is being worked at 8 inches (cut off) that when the lever is dropped to bring a 12-inch cut-off with a 20-inch cylinder that the steam follows the piston at boiler pressure up to this point and uses nearly 1,250 more cubic inches than it did in the 8-inch notch at each stroke.

Therefore the consumption of steam is greater than the amount of fuel fed to the fire; also the water must be increased correspondingly.

61. What should be done when both eccentrics slip?

A. In first method of question 118. B. & M.

62. Tell how you would test for a blow of the admission or exhaust rings of a piston valve engine?

A. Place the engine on the top quarter. Give the engine steam. Reverse the lever from front to back corner; should it pull harder back it would indicate the back end of the valve had defective rings and resulted in unbalancing the valve. Another way would be to set the lever on the center, open the throttle, and watch the stack by putting a little coal on the fire and making a little smoke would show the blow clearly in a double nozzle engine. Should steam show at the cylinder cocks it would indicate in these tests a defective ring.

63. In testing for blows, is it necessary to take into consideration the fact of an engine having a single or double nozzle?

A. It is.

64. How would you test for a blow in by-pass valve of a piston valve engine?

A. Place the engine on the quarter lever in 2-3 gear, open the throttle. Should there be a strong blow at the stack it will show that a by-pass valve was defective, especially so if the blow showed when the crosshead was traveling in one direction.

65. What is a by-pass valve? What is the duty of a by-pass valve?

A. It is a valve forming a communication between the steam cavity in saddle, or main steam channel, and the steam port. To prevent the formation of a vacuum in the cylinder when the engine is drifting.

66. Does the by-pass valve let air in from the atmosphere when the engine is drifting?

A. No, it admits the air that is compressed in one end of the cylinder to flow into the other end through the steam ports and main steam channel, in this way passing the air back and forth between the two ends of the cylinder.

67. How many by-pass valves is each cylinder provided with?

A. Two, one connected with each steam port.

68. What would be the result if a by-pass valve is broken or stuck open?

A. It will cause the engine to blow at the stack, the blow often being mistaken as indicating defective cylinder packing or a defective valve.

69. How would you locate a defective by-pass valve when running? When standing?

A. If the cylinder is fitted with two by-pass valves and one of them is broken or stuck open, the engine will have three clear exhausts and a blow. I would observe the position of the crosshead when the blow takes place; if the blow occurs when the piston is leaving the forward end of the

cylinder it would indicate that the back by-pass valve is defective, and if when the piston is leaving the back end of the cylinder it would indicate that the front by-pass valve is broken. I would place the engine on either the top or bottom quarter on the side to be tested, and with the reverse lever in the forward corner set the driver brake, open the cylinder cocks and give the engine steam. As in this position the back steam port will be open, if steam comes from both cylinder cocks it would indicate that the forward by-pass valve is broken. To test further, would place the reverse lever in the back corner, leaving the engine in the same position; this will open the front steam port, and if steam shows only at the front cylinder cock would feel safe in reporting the front by-pass valve. The other by-pass valve can be tested in this way. If steam shows at both cylinder cocks with the reverse lever in either corner, either both by-pass valves are broken or the cylinder packing is broken.

70. How would you proceed with a badly broken by-pass valve?

A. If the engine was all right otherwise, I would remove the broken by-pass valve, insert a blind gasket between it and the steam chest, and replace the valve.

71. How would you manage in case you found one broken?

A. This depends on the construction of the valve. Should they be bolted on, put in a blind gasket between the valve and cylinder. Should it be a double by-pass valve with a dashpot and tie rod, take out the valve and block it closed, using washers or nuts for the purpose.

72. Describe how the steam enters and is discharged from the cylinders?

A. The valve moves back, opening the steam port; steam enters the cylinder through the steam port and after the valve cuts it off expands to nearly the end of the stroke. The valve then moves ahead, connects the steam and exhaust ports together by its cavity, allowing the steam to pass to the atmosphere.

73. What is the difference between a right and left lead engine?

A. A right lead engine has the main pin 1-4 turn ahead of the left side.

74. If a right lead engine is on the top quarter, what position is the left side in?

A. On the back center.

75. If the reverse lever is placed in the centre when engine is standing as in the last question, what would be the position of the right valve? What would be the position of the left valve?

A. The valve would stand central. The back steam port would be open.

76. What is the vacuum or relief valve on the steam chest for?

A. To allow the engine to draw air into the cylinders when drifting and relieve itself. An engine when shut off and drifting is simply converted into a pump.

77. What would you do in case vacuum relief valve blew out?

A. I would try and plug it, using a chain around the steam chest to hold it in place, wedging it in that position.

78. What would you do in case a gauge cock blew out?

A. Would reduce steam pressure, trying to plug same when steam was down.

79. What would you do in case the throttle stem packing blew out?

A. Try to get in. To clear the main line reduce steam pressure, wrap waste or overalls, or such like around the throttle stem, to get into your terminal, going light.

80. Describe the location of release port in the balance valve, and what it is for?

A. It is located in the center of the exhaust cavity. Its use is to allow any steam that escapes by the packing strips to pass into the exhaust port

and pass out to the atmosphere. If it was not for this the valve would be unbalanced in the event of a slight valve strip leakage.

81. What would you do in case equalizer stand broke on an eight-wheel engine, and it clamped the reach rod between the equalizer and boiler so you could not move your engine?

A. Take out the pin to reach rod at tumbling shaft arm slack off on the counterbalance spring. Work the engine with a light throttle to get into your terminal.

81a. Is the Baker Gear a direct or an indirect motion?

A. It is direct, going ahead for an insided admission and indirect backing up, and just the opposite for the outside admission type.

82b. What are the advantages of the Baker Gear over other valve gears?

A. It is an outside gear having no links or eccentrics. The bearings are all pins and bushings, which makes it very easy to repair. It is also standard, regardless of size or class of engine.

81c. What means are provided to keep the gear properly lubricated?

A. All bearings are provided with a pocket or cavity cast in casting, which does away with the use of oil cups.

81d. What parts of the Baker Gear take the

place of the link which is used by the Stephenson or Walschaert motion?

A. The radius bars and reverse yoke.

81e. What relation to the main pin is the eccentric crank set to?

A. The ecentric crank always follows the main pin.

81f. Should the ecentric rod or eccentric crank break, how is the engine put in condition to proceed?

A. The disabled side can have lap and lead travel and a port opening equal to the lead for all cutoffs. First block the bell crank by using a U bold (which should be provided) in the holes placed in the gear frame for this purpose. Throwing reverse lever in mid-gear will help to get bell crank in position to block. Second, reverse lever in mid-gear will help to get bell crank in position to block. Take down broken parts. Third, knock out back pin of short reach rod and throw reverse yoke in forward motion against gear frame.

81g. What is done should a gear connection rod break?

A. Do the same as for a broken eccentric rod or crank.

81h. What is done should the upper part of gear connection rod break?

A. If break is close to the middle pin, do the

same as for a broken ecentric rod and also tie lower end of gear connection rod to keep it from swinging. If break is near the top and below the jaw, first block the bell crank and wire the connection rod fast to radius bars. If break is through top jaw, do the same as for broken eccentric rod.

81i. What is done should a radius bar break?

A. Do the same as for broken eccentric rod.

81j. If the horizontal arm of bell crank should break?

A. Same as broken eccentric rod.

81k. What is done should the vertical arm or bell crank break?

A. Take down union link combination lever and valve rod, then block valve over ports by using set screw in valve stem crosshead provided for that purpose.

81l. Should you break crosshead arm or union link, what yould you do?

A. If rod be provided to secure lower end of combination lever to guide yoke, remove broken parts and proceed with full train, working engine at long cutoff. Otherwise would remove broken parts, combination lever and valve rod, cover ports and proceed on one side.

81m. What do you do if a union link should break?

A. Same as for a broken crosshead arm.

81n. What is done if a combination lever should break?

A. Tie combination lever plumb same as for a broken crosshead arm, if it is possible. If not possible, take down the combination lever and valve rod and cover the ports.

81o. What is done if a valve rod breaks?

A. Take down the broken parts and cover ports, leaving the rest of the gear intact.

81p. What is done if a reverse yoke breaks?

A. If lugs for holding reach rod break, block yoke securely at whatever cutoff you wish to work the engine and take down the short reach rod. If break is below the lugs, do the same as for broken eccentric rod.

81q. What do you do if reach rod should break?

A. If short reach rod breaks, block the yoke cutoff desired and wire fast so it cannot move. If main reach rod breaks, block between tumbling shaft arm and crosstie brace, wiring same securely.

81r. What is done if the engine breaks down other than valve gear?

A. In this case do the same as for any other valve gear.

202. How could you fill dead engine with no steam or pump to use for this purpose?

A. I would block the relief and by-pass valves closed them, shut off all valves except throttle valve to the injectors. Tow the engine along slowly, causing a vacuum to be formed in the boiler. Open the throttle valve. This will draw the water through the injector into the boiler.

203. To put a dead engine into the engine house how could it be done?

A. By closing the cylinder cocks and other valves, open the throttle, put the lever in the back gear, and then run the engine ahead until you pump up about 70 or 80 pounds of air, being particular to close the throttle when the engine is brought to a standstill. The air pressure obtained will be sufficient to place the engine on the turntable and back it into the engine house. Should it be a short track, it could be done by running forward and back, closing throttle and changing the position of the reverse lever; that is, it must be kept opposite to the direction in which the engine is running, which is now traveling toward the open port, compresses the air into the steam chest, and when the throttle valve is open it flows up hrough the steam passages in the cylinder saddle through branch pipes, dry pipe, throttle pipe to the boiler.

203. Do you know any other method of moving engines by compressed air?

A. Yes. A flue blower hose could be attached to

the relief valves on small engines and successfully move off from a turntable into the engine house.

205. Has this been done?

A. Yes, and with success.

206. Explain how this air pressure is obtained.

A. When the engine is running forward with the lever in the back gear, the exhaust cavity of the valve connects the steam port with the exhaus port, the piston traveling back draws the air down through the exhaust base through the exhaust passage and port through the steam port into the cylinder. When the piston starts back the steam port is opened and the piston forces the air contained in the cylinder into the steam chest and into the boiler through the steam and dry pipes.

90. How would insufficient lubrication on valves and cylinders be detected? How would it affect the working of an engine?

A. It would cause the lever to jump and reduce the power of the engine owing to the excessive friction.

91. What is important to observe in lubricating an engine?

A. Having oil holes clear and packing in the oil cellars in good condition and against the journal lubricators should be started before air pumps are

started, and should be set before the train gets under way.

82. What should be considered a good oil performance with various classes of engines?

Standard 8-wheel engine with 18-inch cylinders should make 90 to 110 miles to the pint of valve oil, and 50 to 70 miles to the pint of engine oil, using the Franklin driving box lubricator. Mogul freight engine 19x26 cylinders should make 75 to 90 miles per pint of valve oil and 45 to 60 miles per pint of engine oil, using Franklin driving box lubricator. Consolidation engines 20 x 30 cylinders should make 65 to 85 miles per pint of valve oil and 40 to 50 miles per pint of engine oil with Franklin driving box club lubricator.

83. What rule can be laid down in computing the valve oil allowed for various classes of engines?

A. Freight service, a 19-inch cylinder, should have an allowance of 85 miles for one pint for each inch of cylinder diameter increase over this, subtract 10 miles and the result will show what the engine should and will do under proper management. For example, to make this answer, clear 19-inch cylinder 85 miles per pint, 20-inch cylinder, 1 inch increase in diameter, reduce miles which will be 75 miles; 21-inch cylinder, 65 miles, etc.

84. What is the number of drops in 3 pints of valve oil?

A. There are 19,800 drops of oil in 3 pints of valve oil.

85. How many drops in 2 pints of valve oil?

A. There are 13,200 drops in 2 pints of valve oil.

86. How many drops in one pint of valve oil?

A. There are about 6,600 drops in one pint of valve oil.

87. How many drops should the lubricator deliver to each cylinder per minute in the various types of engines?

A. Eighteen-inch standard engines 5 to 7 to each cylinder and 2 air pump per minute. Nineteen-inch Mogul freight and passenger engines 5 to 8 drops per minute per cylinder with 2 air pumps and 3 drops per minute, using one air pump 2 drops per minute. Twenty-inch consolidated engines 6 to 9 drops per minute per cylinder, using 2 air pumps, or 1 11-inch air pump 3 drops per minute 9 1-2 air pumps, 3 drops per minute. Twenty-one-inch consolidated engines 7 to 9 drops per minute per cylinder, using 1, 11-inch air pump, or 2 to 9 1-2-inch air pumps, 3 drops per minute.

88. How many hours would an engine run in the first case an 18-inch standard engine run per minute of valve oil?

A. It would run 9 hours.

89. At 20 miles per hour average, how many miles to the pint would be made?

A. One hundred and eighty miles to the pint.

89. Name some of the defects of lubricators?

A. Decrease in Rate of Feed.—A decrease in the rate of feed may be due to any one of these causes:

First: Lack of condensation or steam bound resulting from throttling the boiler or steam valve.

To correct: Keep both valves wide open while lubricator is in operation.

Second: Dirt carried over into the condenser of lubricator from boiler and passing down the water tube will gradually accumulate and reduce the size of water passage, decreasing the amount of water admitted to oil reservoir ,thus displacing a smaller amount of oil and decreasing rate of feed.

To correct: Close all feeds and water valves. Open drain cock and allow about half a pint of water to drain off. Close drain cock and open water valve quickly. The condenser pressure will then force this sediment into the bottom of the lubricator, where it should be allowed to remain until the lubricator is empty of oil. It can then be blown out in the usual manner. If this sediment is allowed to remain in the water passage too long it may solidify so that it cannot be removed by blowing out, in which case it should be reported so that

the obstruction may be bored or cleaned out by a wire.

Irregularity in Rate of Feed.—Irregularity in the rate of feed occurs only in feeds to valves and cylinders and is invariably owing to enlarged choke openings.

To correct: Examine the choke openings and if they have become enlarged beyond the limit required by the particular type of lubricator in use, have them replaced with chokes of proper diameter.

Irregular Feed to Air Pumps.—If feed to air pump or pumps stops and the oil passages are clean it is an indication that the choke in air pump oil pipe connection is clogged.

CHAPTER VII.

Air Brake Examination Questions.

1. What trains is the L Triple used on?

A. High-speed passenger trains.

2. Explain some of the improved features of the L triple valve.

A. It has quick service, high emergency maintaining feature and quick recharging feature. It has no piping to be taken off when detaching from the brake cylinder.

3. Explain the graduated release of the L triple.

A. By this device it is possible to let the brake off, gradually making a smoother stop in long or short trains.

4. Explain how a brake is graduated off with the valve.

A. There are two reservoirs with this equipment; one is called the auxiliary and the other a supplementary reservoir. The supplementary reservoir being the larger. In ordinary service this reservoir (supplementary) is not used.

When graduating off the brake the brake valve handle should be moved to running position for about 4 or 5 seconds and carried back to lap. In doing this we charge the brake pipe enough to move the triple piston to release position and the slide valve opens the communication to the atmosphere; in addition to this opens a communication between the supplementary and auxiliary reservoirs. The air in the supplementary reservoir now feeds into the auxiliary reservoir and raises its pressure until it exceeds the brake pipe pressure. This causes the triple piston to move to lap position, closing the exhaust port, allowing only a portion of the air to escape. The number of graduations should be regulated by the speed and the extent of cylinder pressure obtained.

5. Explain the emergency application with the L valve.

A. The L valve acts similar to the K in venting the brake pipe into the brake cylinder. In addition to this it opens up a direct connection between both supplementary and auxiliary reservoirs, and the combined pressures equalize with the brake cylinder, by which a higher brake cylinder pressure is derived than can be had with the ordinary high speed equipment.

6. What pressure is the safety valve set at?

A. For service applications cylinder pressure is set at sixty-two pounds.

7. How should the brake valve be used on a five or six-car train when releasing? . . .

A. Great many roads recommend using running position only for trains of six cars or less?

8. Why is this?

A. Because the driver brake does not release when in full release position and the slack runs up to the engine causing severe shocks.

9. Is there any danger of the triple valves not releasing on these cars by using the running position for release?

A. Not much on such a short train. The slide valve feed valve gives a good generous flow of air in such a short train.

10. How quick should the high speed reducing valve reduce the pressure after an emergency application is made?

A. It should reduce the brake cylinder pressure

from 85 pounds to 60, which is the adjusting pressure of the high speed reducing valve in about 26 or 27 seconds.

NUMBER FIVE EQUIPMENT.

11. How may the No. 5 equipment be distinguished from the No. 6?

A. By the following method: First, the No. 6 has the Duplex independent air gauge, showing brake pipe and brake cylinder pressures. Second, the reducing valve connection enters the independent valve at the side with the No. 6 and at the bottom with the No. 5. Third, the No. 5 has but three pipes to the independent valve, while the No. 6 has four. Fourth, the No. 6 has a train pipe branch below the cut-out cock leading to the duplex air gauge while the No. 5 has not. The No. 5 has a double cut-out cock on train pipe, the No. 6 has the straight cock. By these methods the No. 5 and No. 6 can be distinguished at a glance.

12. What is the greatest advantage of the No. 6 distributing valve over the No. 5?

A. When using an emergency application with the No. 5, we use the application chamber, with the No. 6 we do not use the application chamber, but the application cylinder only. Supposing with the No. 5 a hose had busted or the conductor's valve opened, and both brake valves in running position,

with the valves in this position there is a direct opening from the application chamber to the atmosphere. Now with the No. 5 the engine brake will release while the train brakes are applied, providing the valve is left in this position. With the No. 6 this cannot happen when an application like the above is caused, because the application chamber is cut out on the No. 6 distributing valve by the equalizing slide valve.

13. What should be done in case one of the swing joints between the engine and the tender (brake pipe fitting) should become broken?

A. Cut out the tender brake at the distributing valve, take down the broken pipe, next disconnect the brake cylinder pipes, connect them to the fitting on the tender and engine that were used by the brake pipe. This will give use of the train brakes, otherwise you would lose the entire train brake and could only use the driver brake on the engine.

14. What is liable to result if brake pipe should become broken between engine and tender; that is, how may the distributing valve act, with the No. 5?

A. Since there will be a sudden reduction on the plain side of the equalizing piston the equalizing valve will move back so far that the main reservoir pressure which passes to the safety valve during an emergency application will have free access

to the application chamber, then when the brake pipe is cut out at the brake valve, the brake will remain applied, and cannot be released without cutting out the main reservoir supply. Should the distributing valve act thus, the only way this could be remedied is to take off the equilizing piston cap (which will be the lower one), push the equalizing piston back as far as it will go. This will close the port which allows the main reservoir pressure to pass in to application chamber. This should be done in case the brake down could not be remedied as stated in the last question, and should you proceed in this way, it will give you the use of the independent valve only.

15. What should be done in case the brake cylinder pipe becomes broken?

A. Cut out the brake cylinder at the distributing valve.

16. How may a broken brake cylinder pipe be detected?

A. When applying the brake the main reservoir pressure will drop and the pump will start to work faster.

17. How do you account for the great reduction in main reservoir pressure?

A. When the air in the pressure chamber passes to application chamber and moves the application piston over, it will stay in that position (application

position) until the pressures are balanced and then the graduating stem and spring moves it to lap position, cutting out main reservoir pressure to brake cylinder. Now let us assume that there is a broken pipe, since the main reservoir supply and brake cylinder pipes are 1-2 inch, it will be impossible to build up a pressure on the brake cylinder side of the application piston. Therefore the application slide valve will remain in application position and allow main reservoir pressure to pass directly to atmosphere via the broken pipe, which will cause a great reduction in the main reservoir pressure.

ADDITIONAL QUESTIONS AND ANSWERS ON THE NO. 6 E. T. EQUIPMENT.

18. Name the different pipes and their connections used with the No. 6 E. T. equipment.

A. Main reservoir pipe, which extends from the main reservoir to the automatic brake valve, with branches to the distributing, feed and reducing valves. Train pipe, which extends from the front of the engine to the rear of tender, with branches to the automatic brake valve, distributing valve, feed valve pipe, which extends from the feed valve to the automatic brake valve. Reducing valve pipe, which extends from the reducing valve to the independent brake valve. Brake cylinder pipes, which

extends from the distributing valve to each brake cylinder on locomotive and tender. The application cylinder pipe, which extends from the distributing valve to the independent brake valve, with a branch to automatic brake valve. Pump Governor pipes, which extend from either the main reservoir or main reservoir pipe, to the governor when single governor head is used. When the S. F. type of pump governor is used, from main reservoir, cut out cock to maximum head, and from feed valve pipe and automatic brake valve to excess head.

19. How many different pressure are used in operating the E. T. equipment?

A. Eight.

20. What are they?

A. Atmosphere, main reservoir, feed valve pipe, equalizing reservoir, pressure chamber, application chamber and cylinder, and brake cylinder pressures.

21. How many pounds pressure to the square inch in the atmosphere?

A. Fourteen and seven-tenths pounds at sea level.

22. Where does main reservoir pressure begin and end?

A. At the discharge valves of the pump, and ends at the reducing, feed, application and automatic rotary valves.

23. The feed valve pipe pressure begins and ends at what point?

A. At the feed valve, and ends at the automatic brake valve.

24. The brake pipe pressure begins and ends where?

A. At the rotary if automatic brake valve, and at the plane side of equalizing piston. Also at plane side of all triple pistons in train.

25. Equalizing reservoir pressure begins and ends where?

A. At the automatic rotary valve, and ends on top of equalizing piston and in equalizing reservoir.

26. Where does pressure chamber pressure begin?

A. At the slide valve of equalizing piston, and ends in the pressure and equalizing slide valve chambers.

27. Application chamber and cylinder pressure begins and ends where?

A. At the equalizing slide valve, and ends in the application chamber cylinder and cylinder pipes.

28. Brake cylinder pressure begins and ends where?

A. At the face of application slide valve, and ends in the brake cylinders.

AUTOMATIC BRAKE VALVE.

29. How many positions has the handle of the automatic brake valve?

A. Six.

30. Name them.

A. Release, running, holding, lap, service and emergency.

31. In release position what ports are open?

A. From main reservoir to train pipe and chamber D, and feed valve pipe to atmosphere through warning port; also from main reservoir to excess pressure head of pump governor, when S. F. type of governor is used.

32. Can the engine and tender brakes be released in the release position with the automatic brake valve?

A. No.

33. Why is this?

A. The connection between the application cylinder and the atmosphere is closed by the rotary valve of the automatic brake valve.

34. In running position what ports are open?

A. From feed valve pipe to train pipe and from train pipe to chamber D, from main reservoir to excess pressure head of the pump governor, when S. F. type of governor is used.

35. Can the engine and tender brakes be released in running position with the automatic brake valve?

A. Yes, providing the independent brake valve is in running position, the application cylinder is connected to the atmosphere through the rotary of the automatic brake valve.

36. In holding position what ports are open?

A. The same as in running position, except that connection between application cylinder and the atmosphere is now closed by the rotary valve of the automatic brake valve.

37. In lap position what ports are open and trace the air?

A. All ports are closed except main reservoir; air can now pass from the top of rotary to feed valve pipe.

38. In service position what ports are open and trace the air?

A. From chamber D to the atmosphere, and from train pipe to atmosphere through the equalizing discharge valve; also from top of rotary to feed valve pipe.

39. In emergency position what ports are open and trace the air?

A. From chamber D and train pipe to the atmosphere, and from main reservoir to application cylinder through the rotary valve; also, from top of rotary to feed valve pipe.

40. How many operating valves are in the E. T. automatic brake valve?

A. Two.

4. Name them.

A. Rotary valve and equalizing discharge valve.

42. Where is the feed valve located?

A. On a bracket, to which is attached the main reservoir and feed valve pipes.

43. What pressure does it control?

A. Train pipe pressure when brake valve handle is in running or holding position.

44. How many air gauges do we have in a locomotive cab when using the E. T. equipment?

A. Two duplex gauges.

45. Name the pipe connections to each gauge hand.

A. On the large gauge the red hand is connected to main reservoir; the black hand to chamber D pressure. On the small gauge the red hand to brake cylinder pressure; the black hand to train pipe pressure.

INDEPENDENT BRAKE VALVE.

46. How many positions has the handle of the independent brake valve?

A. Five.

47. Name them.

A. Release, running, lap, slow and quick application positions.

48. In release position what ports are open and trace the air?

A. From the application cylinder to the atmosphere; also, reducing valve pipe to the atmosphere through the warning port.

49. In running position what ports are open and trace the air?

A. From the distributing valve reservoir pipe to the U-shaped pipe.

50. In lap position what ports are open and trace the air?

A. All ports are closed.

51. In application position what ports are open and trace the air?

A. From reducing valve pipe to application cylinder pipe.

52. What is the normal position of the independent brake valve?

A. Running position.

53. If the brakes are applied with the automatic brake valve, can they be released with the independent brake valve?

A. Yes, by using the release position of the independent brake valve.

54. If the brakes are released by the automatic

brake valve, can they be applied by the independent brake valve?

A. Yes, independent of the train brakes.

55. How many pounds pressure can be obtained in the engine brake cylinder using the independent brake valve?

A. Forty-five pounds.

56. What controls this pressure?

A. A reducing valve.

57. This reducing valve controls the pressure in what other line of pipe on passenger engines?

A. The signal pipe.

58. Why does not the signal whistle blow when the brakes are applied with the independent brake valve?

A. A non-return check valve in the signal line pipe prevents the signal line pressure from being reduced.

59. Where is this check valve located?

A. On the air signal pipe as close to reducing valve pipe as convenient.

DISTRIBUTING VALVE.

60. What takes the place of auxiliary reservoir and triple valves on engine?

A. The distributing valve.

61. How many chambers does the reservoir contain?

A. Two; the pressure and application chambers.

62. Which is the larger?

A. The pressure chamber.

63. How many pipes are connected to the distributing valve reservoir.

A. Five.

64. What are they?

A. Main reservoir supply, application cylinder, distributing valve release, brake pipe branch, and brake cylinder pipes.

65. what pipe connection is at top of reservoir on right side looking at side view?

A. Brake cylinder pipe.

66. What pipe connection is at bottom on right side?

A. The branch from brake pipe.

67. What pipe connection is at top of reservoir on left side?

A. Main reservoir supply to distributing valve.

68. What pipe connection is in centre of reservoir, left side?

A. Application cylinder pipe.

69. What pipe is at the bottom of reservoir on left side?

A. Distributing valve release pipe.

70. How many pistons are in the distributing valve? Name them.

A. Two, equalizing and application piston.

71. What are the duties of the equalizing piston?

A. To open and close the communication between the brake pipe and pressure chamber, and move the slide and graduating valve.

72. What are duties of the graduating valve?

A. To measure the air from the pressure chamber to the application chamber and cylinder in service application. Also in conjunction with the slide valve to open communication between the application cylinder and safety valve.

73. What are the duties of the slide valve?

A. To open the ports between the pressure chamber and application chamber and cylinder when applying the brakes, between application chamber and cylinder to distributing valve release pipe when equalizing piston is in release position. Also to connect the graduating valve from application cylinder to safety valve.

74. Is there an equalizing piston graduating spring in the No. 6 distributing valve?

A. Yes.

75. What are the duties of this graduating spring?

A. To prevent the equalizing piston from moving to the emergency position when a service application of the brake is made.

76. What are the duties of the application piston?

A. To operate the application and exhaust valves.

77. What are the duties of the application valve?

A. To open and close communication between the application chamber and brake cylinders.

78. What are the duties of the exhaust valve?

A. To open and close communication from the brake cylinder to the atmosphere.

79. Where do the engine brake cylinders receive their supply of air from?

A. The main reservoir.

80. What cylinder must be supplied with air pressure before the brake cylinder pressure can be obtained?

A. Application cylinder.

81. How is air admitted to the application cylinder?

A. From the pressure chamber when applying the brakes with the automatic brake valve, from the reducing valve pipe when applying with the independent brake valve, and from main reservoir when automatic brake valve is in emergency position.

82. If the application cylinder contains ten pounds pressure, how many pounds should be in the brake cylinders?

A. Ten pounds, about.

83. What effect will a brake cylinder leak have?

A. No effect on brake cylinder pressure as long as main reservoir pressure can be maintained.

84. Does the brake cylinder pressure vary in this equipment with long or short travel?

A. No; the pressure in application cylinder chamber automatically controls brake cylinder pressure regardless of the piston travel.

85. If with seventy pounds in pressure chamber and nothing in application chamber and cylinder the pressure in these chambers are allowed to equalize, what pressure will they equalize at?

A. About fifty pounds.

86. How many pounds pressure can be obtained in the brake cylinders when using the independent brake valve?

A. Forty-five pounds.

87. Why can we only obtain forty-five pounds?

A. The reducing valve which controls the pressure in application cylinder when using independent brake valve is set at forty-five pounds.

88. Where does the application cylinder receive its supply of air from when the automatic brake valve is in emergency position?

A. From the main reservoir and pressure chamber.

89. What pressure will be maintained in the application cylinder with the automatic brake valve handle in the emergence position?

A. Whatever pressure the safety valve is set at, except when using the high speed brake, when seventy-five pounds will be maintained.

90. What pressure is the safety valve set at?

A. Sixty-eight pounds.

91. In what position of the equalizing piston is communication cut off from the safety valve?

A. Service lap position.

92. If the safety valve is held off its seat from any cause, what effect will it have on the operation of the brakes?

A. It may allow the pressure to escape from application cylinder to atmosphere as fast as it enters, which would prevent you from obtaining any brake cylinder pressure.

93. When double heading, can the brakes be applied and released on the engine not operating the train brakes, independent of the one which is operating the brakes?

A. Yes, by the use of the independent brake valve.

94. Can the engine brake be applied on engines not having main reservoir pressure?

A. No; we must have main reservoir pressure.

95. How is the main reservoir pressure supplied to dead engines and engines with disabled pumps on some roads?

A. By a cut-out cock, check valve and choke

fitting, which forms a by-pass from the brake pipe to main reservoir pipe. The tension of check valve spring being twenty pounds allows a pressure in main reservoir twenty pounds less than carried in the brake pipe.

96. What will cause the brake cylinder pressure to increase when brake valve and equalizing portion of distributing valve is lapped after making a partial service reduction?

A. A leaky independent rotary valve, a leaky equalizing slide or graduating valve, or a leaky distributing valve gasket.

97. What will cause the brake cylinder pressure to decrease after brake valve is lapped?

A. Any leak to atmosphere from application chamber or cylinder.

98. What will cause a continual blow at automatic brake valve exhaust, when handle is in running position?

A. Any leak from main reservoir or pressure chamber to application cylinder or chamber.

99. How can you tell if the leak is from main reservoir or pressure chamber?

A. By closing the cut-out cock in main reservoir supply to distributing valve; if blow stops, it was a main reservoir leak; if not, it is a pressure chamber leak.

100. Can the engine brake be applied with the

automatic brake valve if the independent brake valve is in release position?

A. No; there is direct communication from the application cylinder through the independent brake valve.

101. How can you tell the application valve is leaking?

A. You will have a blow at brake cylinder exhaust when brake is released, and a variable blow when the brake is applied.

102. How can you tell when the exhaust valve is leaking?

A. It will have a constant blow when the brake is applied.

103. What would it be necessary to do in case the brake cylinder pipe broke?

A. If close to the distributing valve chamber, close cut-out cock in main reservoir supply to distributing valve. If beyond the brake cylinder pipe cut-out cock, close the cock and use the tender brake. If in pipe leading to tender brake, beyond cut-out cock, close the cock, which will allow you to use the engine brake.

104. What would it be necessary to do in case the branch from brake pipe broke at distributing valve?

A. Plug brake pipe by cutting out. You can now apply the engine brake with the independent

brake valve, and in the emergency position of the automatic brake valve.

105. What would it be necessary to do if the main reservoir supply pipe broke?

A. Cut it out or plug it. You would not have the use of your engine brake, either independent or automatic.

106. What would it be necessary to do if the application pipe broke?

A. Plug up leak at the distributing valve. You would now have the use of the automatic brake valve only.

107. What would it be necessary to do if you broke the distributing valve exhaust pipe?

A. Proceed with it broken. You would only lose the holding position of the automatic brake valve.

108. What would it be necessary to do if you broke reducing valve pipe?

A. If on an engine not equipped with signal line, slack adjusting nut on reducing valve, which will set the regulating valve, and stop the leak. If on an engine equipped with signal line, and pipe is broken between signal line and independent brake valve, plug the pipe so as to get the use of the signal line. But if broken back of signal line, slack adjusting nut the same as on engine having no signal line.

"SF" PUMP GOVERNOR.

109. How many governor heads are used with the "SF" 3 or 4 type of pump governor?

A. Two, the maximum and excess heads.

110. How can you tell the maximum from the excess head?

A. The excess head has two pipe connections and the maximum one.

111. Name the pipe connections to each head.

A. Main reservoir pressure only is connected to the maximum head, and main reservoir pressure is connected to excess head underneath diaphragm, when automatic brake valve is in release, running or holding positions, and feed valve pipe pressure is connected above the diaphragm.

112. At what pressure should the tension of the spring in each head be set at?

A. In the maximum head, 130 pounds; in the excess head to whatever difference in pressure is desired between the brake pipe and main reservoir pressure.

113. When changing from ordinary quick action to high speed brake when using the "SF" type of pump governor, is it necessary to readjust the spring in excess pressure head of governor?

A. No, as the adjustment in excess governor

head will give the desired amount of excess pressure. It is recommended to set the maximum head at about 133 or 135 pounds with this governor so to prevent the maximum head from opening except when on lap position. That is when using high speed brake. This gives the excess head control of main reservoir pressure in all positions except lap service and emergency.

FUNCTIONS OF THE K TRIPLE VALVE.

114. Why should any improvement in air brake apparatus be necessary?

A. Modern conditions have created new braking problems. The old and well-known (Type H) quick action freight triple valve was designed to meet the requirements of the time when 50-car trains, 30-ton capacity cars, and moderate speed were maximum conditions. But the increased train lengths, speed, and car capacities of the present day have demanded certain modifications to meet these anticipated requirements.

115. What new functions are possessed by the Type K triple valve in addition to those of the old style quick action triple valve?

A. 1st. What is known as quick service. 2d. What is known as uniform release. 3d. What is known as uniform recharge.

116. Why is it necessary to add these features to the triple valve?

A. The quick-service feature was added to bring about a more certain, more uniform, and quicker applications of the brakes in service application on long trains. To make this necessity more clear, it is necessary to have in mind the following: The rate of brake pipe reduction for service applications with the old brake system is determined by the exhaust port in the brake valve. As this is constant, it is plain that the longer the train the slower will be the rate at which pressure in the brake pipe will reduce, and as the air cannot flow to the brake cylinder any more rapidly than brake pipe pressure is being reduced, it is plain that with long trains only a very slow application of the brake takes place, even when it applies at all. This slow rate of brake pipe reduction not only results in a slow application but many times in the failure of individual brakes to apply. This is brought about by the fact that when the pressure is reducing very slowly in the brake pipe it can feed back at the same rate from the auxiliary reservoir, through triple feed port into the brake pipe, and thus there is no difference of pressure created to move the triple valve to application position. Another reason for failure to apply is that even though the triple-valve moves to service position the air flows so slowly from the auxiliary reservoir to the

brake cylinder that it passes through the leakage grooves in the brake cylinder or past the packing leather to the atmosphere, and therefore the pressure does not build up in the cylinder sufficient to force the piston out and the shoes against the wheels. Furthermore, to bring about proper operation of the brakes in a long train not only should the brake pipe pressure be reduced as rapidly, but also as uniformly as possible. As it is impossible to increase the opening at the brake valve without increasing the likelihood of obtaining undesired quick action, and also as it would be certain to bring about a quicker and heavier brake application at the head end of the train than at the rear, with consequent shocks and danger of breaking in two on the recoil, it was found necessary to provide other and local means for reducing the brake pipe pressure more rapidly and uniformly so that these things would be avoided. These means exist in the quick-service feature of the triple valve, which consists of an opening from the brake pipe to the brake cylinder when triple valve is in service position, which port is subject to graduation the same as the ordinary service port of the triple valve. From this it will be seen that when the reduction of the brake pipe pressure is commenced at the brake valve and the first triple valve reaches application position, a supplementary reduction of brake pipe pressure takes place at that

triple valve, thus causing the more rapid application of the next triple valve; this in turn of the next one, and so on through the train, thus producing what may be termed serial application of the brakes. The application, therefore, is as certain and as rapid and free from shocks on a 50-car train with the K valve as it is on a 30-car train with the old triple. The uniform-release feature was added in order that the release of the rear end of the train might take place as rapidly as that at the head end of the train. It is well known that, when a release of the brakes is made, they commence to release at the head end first—in fact, the brakes at the head end are entirely released before those near the rear end commence to release; therefore the slack runs out, resulting in severe shocks and often in breaking the train in two. With the release at the head end retarded, i. e., taking place slower than with the old valve, a simultaneous or uniform release is brought about; thus the slack cannot run out and shocks and break-in-twos are avoided. Thus uniform-release feature consists of a spring placed on the auxiliary reservoir end of the triple valve, with a projecting stem which stops the triple valve slide valve in what is called full-release position (that is, in a position in which the exhaust port is fully opened), unless the pressure in the brake pipe is raised materially higher than that of the auxiliary reservoir. When the

pressure in the brake pipe is increased about three pounds above that of the auxiliary reservoir the spring is compressed and the slide valve consequently makes a further inward travel to retarded-release position, partially closing the exhaust port and thereby making the release of brake cylinder pressure slower than before. In a 50-car train or longer it is impossible to raise the brake pipe pressure three pounds higher than the auxiliary reservoir for more than thirty cars back in the train, even though the engineer holds the brake valve handle in full-release position; therefore, the brake cylinder exhaust is only retarded on the first thirty cars, those beyond that releasing as rapidly as with the old valve; but as those at the head end commence to release first and those at the rear end last, the result in a practically uniform release with consequent lessening of the severity of shocks and decrease in the number of brake-in-twos; making it safer to release a train of fifty cars equipped with K triple valves at low speed than a train of thirty cars equipped with the old valve.

The uniform recharge feature was added to bring about a more uniform recharging of the brakes throughout the train. With the old type of valve the recharge at the head was much more rapid than at the rear because of the higher pressure at the head end when brakes were being released. This often

brought about a reapplication of the brakes when the handle was returned to running position and was largely responsible for stuck brakes. Uniform recharge lessens this very objectionable feature to a marked degree, and, in addition, if a re-application is made shortly after a release the brakes apply much more uniformly and certainly than is the case when the auxiliary reservoirs are charged much higher at the front than towards the rear of the train. This uniform recharge is brought about by decreasing the size of the charging port or grooves when the triple valve is in retarded-release position; and as this can only be when the pressure in the brake pipe is higher than that in the auxiliary reservoir, it is seen that when the pressure is the highest the charging ports are the smallest, while when the pressure is the lowest, as at the rear end, the charging ports are the largest; thus the recharge is more uniform because the high pressure will charge as quickly through a small port as the low pressure will through a large port.

From the above it will be seen that certain undesirable features of the former valves have been overcome and the following additional features derived:

(1) More uniform charging of the entire train, consequently more uniform cylinder pressure and application of the brakes.

(2) Ability to remain in released position longer

without overcharging the forward end of the train (avoiding the resultant re-application of the brakes due to back flow of air).

(3) Greater volume and pressure of air flowing toward the rear end of the train.

(4) Saving of air which would otherwise go to the auxiliary reservoir, then to the cylinders by re-application of the brake and to the atmosphere through the triple valves, this saving being due to the small charging ports preventing the overcharging of auxiliaries.

From the foregoing it is evident that the feature referred to is in reality a "uniform recharge" rather than a retarded recharge, and while it is true that in very short trains the recharge would be retarded (as compared with valves having the maximum permissible feed grooves, but not as compared with those having the maximum size feed grooves), in long trains as a whole the recharge will be as rapid as at present, and when the retarded release feature which operates as an automatic retainer is considered, as well as the fact that a given reduction produces a greater retardation, an effective recharge is much more quickly accomplished.

117. What is claimed for this valve?

A. A much better control of the train by the engineer, shorter stops, reduction of shocks and brake-

in-twos, greater freedom from undesired quick action and greatly reduced air consumption.

118. What increase of brake cylinder pressure is obtained by use of the quick-service ports?

A. About one pound higher equalization under equal conditions.

119. Is the quick service feature operative with short trains?

A. No. This feature automatically goes out of service whenever the brake pipe pressure is being reduced at the proper rate.

120. Why is undesired quick action less likely with "K" valve than with the old?

A. Because of the construction of the valves and due to the quick-service feature, which reduces the brake pipe pressure more uniformly.

121. With this type of valve will not the release be slower with the short trains than is the case with the old type of valve?

A. Yes, and at the first this may appear somewhat objectionable. But when the proper way to operate is understood these objections disappear, and it simply means release the brakes a little earlier than with the old type; and as the benefits obtained are so great and so necessary, this feature must be overlooked in view of the fact that much worse results and delays on the road are unavoidable with the old type when long trains are being handled.

122. What will be the effect of releasing the brakes before coming to a stop with a 25 or 30-car train having only one or two Type K triple valves and these located near the rear end?

A. With such short trains the danger of a brake-in-two in releasing practically disappears, as there is not enough slack to produce this effect. In such case even if one or two K triple valves were near the rear end and go to retarded release position it would not be objectionable:

(1) Because of the short length of train as heretofore explained.

(2) Because the effect would be no more undesirable than that commonly existing on similar trains with uniform equipment throughout, but with the piston travel varying on the cars as it does in ordinary service.

123. What will be the effect of releasing the brakes before coming to a stop with a 25 or 30-car train having only one or two Type K triple valves, and these located near the front end?

A. These triple valves will go to Retarded Release Position, but the effect would be beneficial instead of objectionable, since it would be the equivalent of holding the locomotive brakes applied while releasing the train brakes in order to keep the slack bunched and prevent the head cars from running

away from those on the rear end and perhaps pulling the train in two.

124. Cannot the brakes be released more quickly by only using the running position with short trains?

A. Often, yes, but it is better to operate in the usual way; commencing the release earlier if it is desired to release and keep moving.

125. How can the brake be most quickly released by means of the release valve on the auxiliary reservoir when there is air in the brake pipe?

A. Reduce the auxiliary reservoir pressure slightly below brake pipe pressure, when the triple valve will go to release position but not to retarded release Position, and the release will be as rapid as with H-type of valve. If the auxiliary reservoir is reduced much below the brake pipe the triple valve will go to retarded release position and the release will be slower.

126. How should the brake be released when there is no air in the brake pipe?

A. In the usual way, that is, by holding the release valve open until all the air has escaped.

127. How is the greater efficiency of the "K" valve accounted for when only such a slight final increase of cylinder pressure is obtained?

A. 1st. The brakes apply in less time with long trains than with the old valves.

2nd. All brakes apply.

3rd. The air flowing to the cylinders through the quick-service ports equals the displacement of the brake cylinder piston, therefore making the brake more effective for light reductions.

128. How can you bleed off a K triple?

A. Close the cut-out cock, which will allow both sides of the triple piston to become equalized in pressure and the retarding spring will force it to release position. After it is released cut the valve in again slowly.

129. How is the automatic brake applied? How released?

A. By moving the brake valve to service position a reduction is made in chamber D and equalizing reservoir. The brake pipe pressure then being greater on under side of the equalizing piston causes it to rise and opening the brake pipe exhaust causing a reduction in the brake pipe and the triple valves to move to application position. When the brake valve is placed in full release position there is a direct communication between the brake pipe and main reservoir through the rotary valve; this charges the brake pipe and forces triple valves to release position.

130. How should the steam cylinder of the air pump be lubricated?

A. By the lubricator and should receive from 2 to 3 drops per minute.

131. How should the air cylinder be lubricated?

A. By valve oil through the cup provided for the purpose on the air cylinder.

132. Is there anything else about the air pump to be lubricated?

A. Yes, the piston rod.

133. Whnat kind of oil only should be used about the pump?

A. Valve oil.

134. If the air pump stops, what should be done?

A. Should it stop between stations I would try and make the next station on a local train and perfectly tight brake pipe. After arriving would try to start it.

135. How would you try to start it?

A. Would shut the throttle valve off, reduce main reservoir pressure and open it up quickly again. I would also try to start the reverse valve by tapping it lightly. I would also, if necessary, take the plug out of the bottom cylinder head to see if the nuts were loose on the air piston rod.

136. Why should not engine, or other light bodied oil be used in the air pump?

A. Its flash point is too low; it would therefore burn and lose its lubricating quality.

137. What are the positions of the Westing-

house 1892 model brake valve handle? State what each is for?

A. Full release running lap service and emergency.

Full release to release the brakes running to get the use of the feed valve and excess pressure.

Service for service application of the brake emergency for an emergency application.

138. If the air pump makes a quick stroke one way and slow the other, what would be the cause? How could it be quickly determined which end of the air cylinder was defective?

A. A broken or stuck air admission or discharge valve. Open the cylinder cocks to the pump the one that blows the least would indicate the defect is on the opposite side of the piston in the air cylinder. I could also tell the defective valve by holding my hand over the air strainer, noting the amount of air drawn at each end of the piston. The side drawing little or no air would indicate the defect was on that side of the air piston.

139. How would you test for leaky air packing rings in the air cylinders?

A. Cut out the main reservoir cock and note the speed of the pump. With no cut-out cock place the brake valve on lap after making sure that there are no pipes leaking and note the speed of the pump. Should it run at the rate of 6 to 10 strokes per minute

or more it will be evident that the rings need renewing, the amount of leakage depending on the speed of the pump.

140. How would you test for a main reservoir leak?

A. Place the brake valve handle on lap, take a torch and examine all pipe fittings to the main reservoir. Also note condition of the seams and drip cock in the main reservoir.

141. What equipment besides the air brake is main reservoir pressure used for?

A.E The bell ringer, sand blower and water scoop.

142. What valve or valves does the main reservoir pressure have to pass through to get into the brake pipe?

A. The rotary and feed valves.

143. Describe the passage of air after leaving the brake valve.

A. Through the brake pipe to the plain side of the triple valves, through the feed ports in the triple piston to the auxiliary reservoir.

144. Where does brake pipe pressure end?

A. At the triple piston plain side.

145. Where does the auxiliary reservoir pressure begin?

A. At the triple piston auxiliary side.

146. What is the standard auxiliary reservoir

pressure? What is the auxiliary reservoir pressure when using the high speed brake?

A. Seventy pounds—110 pounds.

147. To what is the brake pipe connected under an engine, tender or car?

A. The triple valve.

148. To what is the triple valve connected?

A. The auxiliary reservoir and brake cylinder.

149. Where is the pressure stored for applying the automatic brake? Where is it stored for releasing?

A. In the auxiliary reservoir. In the main reservoir.

150. Does the main reservoir pressure increase as the brake is applied?

A. With some equipments using the Duplex governor.

151. How should a governor having two tops be adjusted? Explain how the pressure is increased when applying brakes with the Westinghouse 1892 model valve.

A. Place the brake valve handle on lap; this will give connection to the maximum head; set the maximum head by its adjusting screw; set the excess head by setting the feed valve at brake pipe pressure, say 110. Then have the brake valve on running position, adjust the screw on the governor top to give 20 pounds more than brake pipe.

B. With this attachment there is used a duplex governor, one spring adjusted at 90 the other at 110 pounds, for the purpose of increasing main reservoir capacity for releasing. The low tension governor head is piped direct into the feed valve port between the rotary valve seat and the feed valve. By moving the brake valve handle to lap cuts out the low pressure head and the pressure is released through the relief port in the governor, causing it to start. The high tension head is connected direct to the main reservoir. When the pressure reaches 110 pounds opens the pin valve and stops the pump, as explained in B. & M. examination.

152. How long should the handle of the brake valve be held in release position when releasing brakes with a passenger train? With a freight train?

A. With the E. T. Equipment on a passenger train just for a second; to avoid shocks due to driver brake holding on. Some roads recommend using running position only with six cars or less.

Freight trains according to their length generate until both hands equalize, moving to release for intervals of 3 to 5 seconds to avoid overcharge of train line on the head end.

How is the brake power figured by the locomotives brake cylinder and levers?

Multiply the area of the brake cylinder by its

pressure and then by the long end of the brake lever and divide by the distance from the point of the fulcum to the brake rod. For example: Take a 15-inch brake cylinder with E. T. Equipment independent brake valve in application position, giving 45 pounds brake cylinder pressure. The area of the brake cylinder in square inches is 177, about this multiplied by the pressure per square inch, which is 45, gives us 7,965 pounds; this multiplied by the long end of the brake lever, measured from the fulcum, for instance, say it is 20 inches. The total moment of force is now 7965x20, and say the short end of the lever is 8 inches from the center of the fulcum. The total force which gives us 19,912 pounds.

How could this power be used advantageously in the event of a broken cylinder head or similar defect, causing the engine to become stuck on the dead center?

I have used a piece of rail passed between the spokes of the forward drivers, blocked up to the brake levers, and letting out on the adjusting screws on the brake gear, applied the brake and the force of the two driver brake cylinders pulled the engine off from the center.

153. What would you do if you did overcharge a train when standing? What if running?

A. I would reduce brake pipe pressure. Below

the feed valve adjustment release and move the brake valve to running position. Keep the brake valve in full release position until the next stop, then reduce below the feed valve adjustment.

154. How long should the brake valve handle be held in release position with a lone engine?

A. Just for the length of time it takes to go to release and back to runnning again.

155. In making a terminal test of the brakes, on a train, how could you determine the amount of leakage in the brake pipe?

A. After the brake pipe exhaust closes note the amount the black hand drops. It is leakage.

156. How could you test for a leak in the air signal pipe on the engine?

A. Cut out the reducing valve; should the whistle blow there would be a leak in the equipment.

157. How can you test the air gauge by means of the brake valve?

A. Place the brake valve in full release position and note the position of both red and black hands; they should be together.

158. How could you test the signal line pressure?

A. Close the pump throttle. Open the brake pipe angle cock slightly in front of the engine; place the brake valve in running position; watch the red hand on the air gauge fall; when the whistle starts to blow it shows signal line pressure at the engine

house; put the test gauge on the hose; open the signal line cock.

159. What would you do if you had a broken brake pipe under the tender of a passenger engine?

A. Connect the signal line under tender to the brake pipe connection on the engine and to the brake pipe on the car. This will cut out your tender brake and air signal only.

160. If the brake pipe on a passenger engine was broken, what would you do?

A. Reduce main reservoir pressure to brake pipe pressure. Screw up on the air signal reducing valve; place the automatic brake valve on lap position; connect signal line on the engine to brake pipe of the tender; this will charge the brake pipe via. signal reducing valve. To apply the brake move the handle of brake valve to full release position, causing a reduction in main reservoir pressure, and at the same time brake pipe pressure via. signal line on engine. (See similar pipe brake downs on E. T. Equipment.)

161. What two pressures operate the triple valve in applying and releasing the brakes?

A. Brake pipe and auxiliary pressures.

162. How many times does the air pass through the triple valve?

A. Three times.

163. Which pressure moves the triple piston to apply the brake? Which to release?

A. Auxiliary. Brake pipe pressure.

164. If you reduce brake pipe pressure five pounds, how much pressure will leave the auxiliary reservoir, and go to the brake cylinder? If you reduce ten pounds? Twenty? Why did not more leave the auxiliary reservoir after you reduced twenty pounds?

A. About 5 or 6 pounds. About 10 or 11 pounds. Twenty will equalize the auxiliary and brake cylinder. Because the auxiliary and brake cylinder equalized.

165. Would a further reduction of brake pipe pressure apply the brake any harder? No. Why?

A. Because the brake cylinder and auxiliary reservoir have equalized.

166. What pressure should you have before testing brakes?

A. Full brake pipe and main reservoir pressures.

167. When applying brakes can you tell about how many cars of air are coupled up? Yes. How?

A. By the length of the blow from the brake pipe exhaust.

168. When applying brakes, if the brake pipe exhaust at the brake valve is weak, what does it denote?

A. A restriction in the brake pipe, loose lining in

an air hose, an angle cock partially closed. Loose rings in the equalizing piston of the brake valve would cause this also.

169. When double heading, which engineer should control the brakes? What should the other engineer do?

A. The engineer on the leading engine. He should cut out his brake valve.

170. Could you tell from the head engine if he had? How?

A. I would test the brake after coupling on should my reduction be pumped off. I would know he had not cut out his brake valve.

171. What effect would it have if double heading they had not cut out their valve when you attempted to apply the brakes?

A. I could not get a reduction in the brake pipe; the second engine would pump off my reduction and no application of the brake would result.

172. In making a two-application stop, how should the brake valve be handled, so that the brakes will respond promptly to the first reduction of the second application?

A. On lap position this will give a more even pressure in the auxiliary and brake pipe. Otherwise in running position brake pipe pressure would be higher than auxiliary and you would have to reduce this before you could get the triple piston to move

173. Why is it dangerous to apply and release the brakes repeatedly when making a station stop?

A. Might cause entire loss of air and no brake at all.

174. Does a long train require any greater reduction than short one?

A. Generally it is a good plan to reduce 10 pounds for the first 10 cars and 1 pound for each 10 after that. Thus 30 cars, about 12 pounds; 50 cars, 15 pounds, etc.

175. When do you consider the most important time to look at your air gauge?

A. Before descending grades, approaching meeting points and junction points, ends of double track, etc.

176. What position of the brake valve should be used when recharging on a grade?

A. Full release.

177. Why should you open the angle cock on the rear end of tender, especially in cold weather before leaving the roundhouse?

A. To see that it is not frozen.

178. What defects in the Westinghouse brake valve would prevent excess pressure being carried?

A. A leaky rotary valve leak between the feed valve and brake valve gasket, a leak in the lower brake valve gasket, a logy or stuck feed valve.

179. How could a leak in the rotary valve, or

lower gasket, be distinguished from a leak in the feed valve attachment, or the gasket between it and the brake valve?

A. You would have no excess pressure should the rotary leak; it would charge the brake pipe on lap, using the regular test (see B. & M. examination). Should it not charge brake pipe on lap it would be the feed valve or gasket.

180. If the driver brake gradually leaks off after an application, without an exhaust through the triple valve, what would you report?

A. Examine piping from triple valve to brake cylinder, also packing leather in the brake cylinder and head gasket.

181. What would you do if the pipe to the Westinghouse single governor broke off?

A. Plug the end of the broken pipe, throttle the pump to the desired pressure.

182. If the signal whistle gives a weak blast what may be wrong?

A. The reducing valve may be too lightly adjusted. The rubber diaphram may be bagged or a small hole in it.

183. If the signal line was fully charged what would cause it not to respond to a reduction in pressure?

A. Bagged diaphram or broken whistle plugged by wedging waste between it and the cab, whistle

loose on its stem or the whistle pipe broken and leaking.

184. What would be the effect of applying the straight air and then the automatic, using the double check valve? Would there be any bad effect when the automatic brake was applied if the straight air was applied before the automatic was released?

A. These may cause the brake to stick when the automatic valve is applied, the air would force the double check over, stopping the flow to the straight air brake valve and could not release it with the straight air valve, not if the reducing valve is O. K. To release put both valves in release position.

185. What defect would cause a blow at the exhaust port of a plain triple valve?

A. A leaky emergency valve.

186. What would cause a blow at the triple valve exhaust when the straight air was applied? What would cause a blow at the straight air brake valve when the automatic brake was applied?

A. A leaky double check valve.

187. Why will brakes apply, if you leave the handle of the brake valve too long in full release before going to running position, if there are leaks in the brake pipe?

A. The feed valve pressure is exceeded by 20 pounds. No air can pass into the brake pipe. The

leakages reduce the brake pipe pressure and apply the brakes.

188. What is meant by a reduction?

A. Making a reduction in chamber D causes a drawing air from the train pipe through the automatic brake valve.

189. How much of a reduction should be made for the first, when making an ordinary stop? After the first reduction how heavy should the succeeding ones be?

A. About 8 to 10 pounds, 3 to 5 pounds. With the modern triple valves.

190. Do you consider a one or two application stop best with a passenger train? Why?

A. Two. Because the second is lighter and does not tilt the trucks causing a recoil.

191. How should stops with the high speed brake be made?

A. Two applications.

192. If stopped on a grade would you depend on the air brakes to hold the train any length of time? Why?

A. No. Because the air would leak from the brake cylinder and auxiliary via. triple valve and the brake cylinder packing leathers.

193. How heavy a reduction should be made for a first one, on a heavy grade, with a train of 20 to 40 cars? With 40 to 60 cars?

A. Ten pounds, 15 pounds.

194. If black hand on gauge kept falling, due to the brake pipe leakage and the train did not slow up, what should you do?

A. Call for hand brakes.

195. What do you understand causes trains to get away on descending grades when being handled with air brakes?

A. Too frequent applications and not allowing time to charge auxiliaries and not using retainers.

196. Suppose the driving wheel tires were overheating when using the automatic brake, what would you do?

A. Release the straight air valve.

197. In steadying a passenger train around a curve, where should the brakes be applied? Where should they be released?

A. Just before coming on the curve. When leaving the curve.

198. If you knew that you were sliding driving wheels when making a stop, what would you do? How would you prevent it at the next stop?

A. Open the throttle quickly to try to start them revolving. Have sand running before applying the brake.

199. If the rear brakes fail to release readily, what is the best way to release them?

A. Make a heavy reduction and release.

200. How would you release the brakes on a freight train, when running, if engine was equipped with a straight air brake?

A. Hold the driver brake on to prevent shocks.

How could you operate the train brakes in the event of breaking the brake pipe from the automatic brake valve with this equipment?

A. Cut out the driver brake, disconnect the brake cylinder pipe and connect it to the train pipe between engine and tender.

Reduce the main reservoir pressure to brake pipe pressure. Block the application piston to application position plug distributing valve exhaust. This will charge the train pipe via the distributing valve. Place the automatic valve on lap.

To apply the brake move the handle of the automatic valve to release, which will cause a reduction in the brake pipe and in an application.

How is retardation or brake power of a train computed to know about how far a train will run after an application of the brake?

A. This question involves Newton's second law of motion, which states (a change of momentum is proportioned to the impressed force and takes place in the direction of the force), or in other words the brake power must be a certain proportion of the total force of the train.

Let us assume the train has a mass of 200 tons (mass is the weight of a body divided by gravity or 32.2 pounds) and running at 30 miles per hour is brought to a stop in 20 seconds, find the average braking power 30 miles per hour=44 feet per second, momentum in pounds in one second is 200x2,000x44.

Let X=brake power the total force now is 20X =200x2,000x44 or X=880,000 poundals (the action of one pound in one second) or 27,500 pounds. For brake power retardation will be

$$\frac{\text{Force}}{\text{Mass}} \text{ or } \frac{880000}{200\text{x}2000} = \frac{11}{5}$$

feet per second each second. This represents the actual retardation of the brake mechanism for each second after the brake is applied. The space traveled will be ½ the acceleration multiplied by the square of the time which is 20 seconds, hence 1/2x11/5x20x20=440 feet.

CHAPTER VIII.

Computing Tonnage Rating and Other Resistances.

1. How is the resistance of a train up a grade found or how is the tonnage rating figured for the ruling grade on a division

A. The resistance of trains due to the grade can be found by dividing the rise of the grade by its length; for instance, a grade 5,000 feet long raises 50 feet, then 50/5,000=1/100, multiplying this by 2,000 we have 20 lbs. resistance per ton due to grade. In addition to this we have the resistance of the air which is the product of multiplying .007 by the square of the speed of the train, adding 9 to this. For example, 15 miles per hour = 225, which is the square of the speed, and multiplying by .007 we have 1.6, very nearly adding 9 we have 10.6 per ton resistance for the speeds, due to the air resistance. Adding this to the resistance per ton on act of grade we have 30.6 pounds per ton. In this case assume an engine to be of 40,000 pounds, tractive power and the 1 per cent. grade without curves, the weight of the engine, 110 tons or about 85 tons on drivers, the resistance per ton of 2,000 pounds is 22.2 times the weight carried on drivers. This is due to friction of the driving wheels journals, cross heads, etc., which must be subtracted from the tractive effort of the engine. In this case it is the product of 85x22.2, equal to 1887. Suppose the weight carried on the engine truck to be 12 tons, this figured at the same rate as a car, would be equal to 367 pounds; suppose also the weight of the tender to be 72.6 tons, taking an average of two-thirds of this for the varying amount of water and fuel carried in the tender,

we have 48.4 tons to this, the same resistance is applied as is to a car of the same weight we would have 1,887 pounds, and the total power utilized to overcome the resistance will be as given here, namely: Weight on drivers 1,887, on engine 367, on tender 1,481, as a total 3,735, subtracting this from 40,000 pounds, the tractive force, we have 36,200 very nearly available for hauling the train; dividing this by 30.6, the resistance per ton, which gives 1,117 tons allowed on this particular grade. Now subtracting about 10 per cent. for varying conditions of steam pressure and conditions of the engines, we have 1,010 tons about.

2. How is the resistance figured on a curve?

A. The resistance per ton on a curve is found by multiplying the degree of curvature by .08, for example, a 5-degree curve train of 1,000 tons would be 4,000 pounds resistance, which would have to be deducted as in the case in the foregoing question.

There are several formulas for train resistance, some of the principal and latest are as follows: By New York Central is given as 1.8+1/9 velocity in miles per hour per ton on level track. The resistance on grade is found by the dividing of the rise in feet by the length. There are several formulas for atmospheric resistance, the last named is quite practical.

3. Why is the tractive force of an engine greatly increased with a slight increase in cylinder diameter?

A. The product of the force in pounds in the cylinder is equal to the steam pressure multiplied by the number of square inches of the piston. Since this holds true, it is evident that a slight increase in the diameter of the cylinder will increase the number of square inches on the piston, which multiplied by the steam pressure will give the force exerted in pounds.

A circle increased double its diameter results in four times the area of the cylinder or circle, thus a 10 inch circle has an area of 78.54 square inches; a 20 inch has 314.16 or four times the area in square inches. The difference in the area in square inches of 19 inch and 22 inch cylinders is 283.5 for the 19 inch and 452 for the 22 inch, or a difference of 168.9 square inches in favor of the 22 inch cylinder.

4. Suppose the both engines are starting a train and the steam admitted to the cylinders is 170, which is 85 per cent. of 200 pounds used in calculating tractive force, and each engine carrying 200 lbs. of steam in the example?

A. The force of steam and square inches available will be 452x170 in the 22 inch cylinder engine and 283.5x170 in the 19 inch cylinder engine, which is equal to 76,840 for the 22 inch and 48,195 for the 19 inch or a difference of 28,645 pounds in favor of the 22 inch engine.

Now since all steam pressure is known by the square inch, the number of square inches found, and

multiplying by the pressure will give the force in pounds.

5. Explain how resistance by back pressure or an engine chocked up acts as a retarder of a train's movement?

A. The back pressure or resistance to the piston movement is the number of pounds back pressure, multiplied by the area of the piston; for example, in the 22 inch cylinder 452 square inches 5 pounds. Back pressure, which is equal to 2,160 pounds resistance from this cause.

6. How is the elevation of the outer rail calculated on curves?

A. The speed when rounding curves involve the principles laid down in Newton's laws of motion; however, a rule is used to give the amount of elevation as follows: Multiply the degree of the curve by .00069 and this sum by the velocity in miles per hour squared or multiplied by itself, thus a 6 degree curve limit of speed, 40 miles per hour.

.00069x6 = .00414, and this by 40 miles per hour multiplied by itself, we have .0014x1,600 = 6.624 or 6 3/4 inches for the outer rail.

8. How is a grade determined in per cent.?

A. One per cent grade would have an incline of 1 foot in a 100 of length or a rise of 52.8 feet per mile, a 3-4 per cent. grade would rise 9 inches in 100 feet or 47 1-2 feet per mile. To find the rise per

mile multiply 5,280 by the terms in per cent., thus 5,280x.01 = 52.8 per mile, or take the case of a 2 per cent. grade 5,280x.02 would equal 105.6 feet per mile.

CHAPTER IX.

Questions on Locomotive Design.

1. What is taken as a factor of adhesion on locomotives?

A. Generally 1-4 of the weight on drivers is taken as the factor.

2. Suppose an engine had solid counterbalances. How would you determine the weight of them?

A. By the following method. You could come very close; take a pair of calipers and divide the counterbalance at its outer edge, find the number of inches then find the entire circumference of the wheel center by multiplying the diameter of the wheel center by 3.1416, this will give you the circumference of the wheel. Then by geometry the area of the sector of a circle is to the area of the circle as the arc of the sector is to the entire circumference. Assume the wheel center to be 46 inches in diameter and the arc of the counterbalance to be 56 inches, then by letting X equal the sector we have $\frac{X}{2116} = \frac{46}{144}$ which gives X = 676 very nearly. This being the area of the entire sector of

the circle, now since the side nearest the center of the axle is straight it forms a chord of the circle, therefore the wheel center being 46 inches lines from the edge of the counterbalance to the center of the axle will form a triangle, since the area of a triangle is the product of the base times twice altitude divided by 2, we have by this means the area of the triangle between the counterbalance and the center by the axle.

Now assume the triangle to be 7 1-2 inches from the center of the axle and it's chord 56 inches in length. $\frac{7\frac{1}{2} \times 56}{2}$ equals 210 the area of the triangle subtracting this from the entire area of the sector we have 466 inches, the area of the counterbalance in square inches.

To find the weight of the counterbalance it is necessary to know the number of cubic inches in the counterbalance, therefore 466 being the number of square inches, multiplying this by the thickness, assume it to be 8 inches, which is 8x466 = 3,728 cubic inches. Since there are 1,728 inches in 1 cubic foot, dividing 3,728 by 1,728, we have 2.13 cubic feet. The weight per cubic foot of cast iron or cast steel is 450 lbs., therefore the weight of the counterbalance will be about 950 lbs. From this area the number of spokes that pass through the counterbalance could be figured and the same subtracted from the weight of the counterbalance. A convenient way of getting this

would be to multiply the thickness of the spoke by its width and then by .7854 and this sum by its length passing through the counterbalance. Multiply this by the weight of the metal per cubic inch, subtracting the same from the counterbalance. There is also another method of finding the square inches in the counterbalance. The following can be used $\frac{4H^2}{3} x \sqrt{\frac{2R}{H}} - .608$ where H equals the height of the counterbalance at its middle point and R the radius of the circle. How can improper counterbalances be determined from observation? The American Master Mechanics' Association have a rule which states that 399/400 of the reciprotating parts. Some builders use a maximum of 65 per cent. and a minimum of 55 per cent. Reciprocating parts consist of piston, piston rod, main and side rods. The entire weight of the main rod is not taken as a reciprocating part.

A good method of observing improper counterbalancing: Should the engine have a nosing action it is evident that the rods are heavier and are out of balance; on the other hand should we have vertical action or an upward pull so to speak when the engine is passing the top quarter; this may also cause the engine to slip shut-off owing to the tremendous inirtia set up by the driving wheels at high speed in addition to its liability to derail the engine. The factor of adhesion of the engine will be less under such circum-

stances at some points of the stroke, as there is a tendency to lift the engine while the counterbalance is passing upward. It also exerts a great strain on the rails while passing downward. If the factor of adhesion is less while the counterbalance is coming up the liability for the engine to start slipping at this point is quite evident and the great centrifugal force when once started will not recede until the forces are nearly normal, that is, slowed down materially.

3. What are some other causes of an engine slipping shut-off?

A. Excessive cylinder compression is said to be a sufficient cause for this.

4. Explain clearly why an engine wears more on the left side in service?

A. The left driving box will wear greater on account of the unbalanced portion of the engine while running ahead, coming on that side. To explain, starting forward on the back center right side the engine takes steam and pulls the driving box ahead against the shoe, now follow this up to the top quarter until the left side begins to pull the left side ahead in the same manner, now both driving boxes are against the forward wedges or shoes when the right side gets to the forward center the driving box is released and the steam in the left cylinder forces it back to the back wedge or shoe through the fulcrum of the left driving box, now the right cylinder takes

steam again and pushes the driving box, which is now against the back wedge or shoe, and is held there until the left side gets to its forward center. This brings the right side on the lower quarter and as release takes place in the left cylinder, the driving box is brought back against the front shoe or wedge by the right side through the fulcrum of the right driving box. Or, in other words, the driving box on the right side is always against the shoe or wedge while the left side has to take its slack up before the power can be applied.

During this motion ahead the right driving box receives but one pound or tendencies to pound in one revolution, while the left side receives two for each revolution. Should the engine be run backwards the same conditions would appear on the right driving box.

5. What advantage is gained in using an inside admission piston valve?

A. An inside admission piston valve is much easier on valve stem packing and but one size of valve chamber bushings are necessary while on the outside two sizes are required generally.

6. Which end of the valve chamber is the larger bushing on?

A. On the rear end.

7. Why are two sizes of valve chamber bushings used?

A. A large bushing is used for the purpose of compensating the space used by the valve stem in this chamber.

8. What is the inside admission valve sometimes called?

A. An indirect valve.

9. Why is it called an indirect valve?

A. Because it moves opposite to an ordinary slide valve and opposite to an outside admission piston valve.

10. Suppose the engine had an outside admission valve and it was changed to indirect motion and no changes in the valve gear, what would result?

A. The engine would back up in the forward gear and run ahead in the back gear.

11. How is this overcome?

A. On some roads all eccentrics are set 90 degrees minus lap and lead behind the main pin.

12. How would you figure the tractive power of an engine?

A. By multiplying the diameter of the cylinder by itself in inches and this by its stroke and then 85 per cent. of the boiler pressure and the same dividend by the diameter of the wheel in inches. Subtract 10 per cent. for friction.

13. Explain how you would find the stroke?

A. Measure the distance from the center of the main axle to the main pin and multiply by 2. If this

distance from the main pin to axle is 15 inches x 2 which is equal to a 30-inch stroke.

14. Explain how you would find height of wheel?

A. To find height of wheel measure the distance from the outside of the tire to the center of the axle and multiply by 2. The measurements can be done much quicker than using the entire distances.

15. How would you get the 85 per cent. of the boiler pressure?

A. With 200 pounds, subtract 30 from boiler pressure; if 190, subtract 28.5; if 180, subtract 27; if 160, subtract 24; if 150, subtract 22.5.

16. How, after finding the tractive power, would you tell the tonnage the engine would haul over a division giving the rating in its time card and tractive power of its engines?

A. Divide the tractive power into the tractive power of the 100 class or 100 per cent. engines shown in the time card; should it be 90 per cent., for instance, multiply the 100 class engine by .90 and it is the desired tonnage rating.

17. How is the tractive power of an engine compared with other proportions of the engine?

A. Tractive power of the engine is 23 to 26 per cent. of the weight on drivers; for instance, take an engine carrying 85 tons on drivers, or 170,000 pounds, we have 170,000×.26%=46,200, the tractive power

of the engine, on modern locomotives; this will come quite close to the rating.

33. What rule is used for the size of steam ports on locomotives?

A. It is taken 1-10 to 1-12 of the area of the cylinder. For instance, take the area of a 20-inch cylinder which is the process of 20 x 20 multiplied by .7854 and divide this by 12, the result is 26 inches nearly, since on consolidation 1½-inch steam ports are used dividing 1 and ½ into 26. We have a steam port 18 2-3 long, or 18½ to simplify this rule 20 x 20 x .7854 and divide by 12.

38. Is the range of cut-off changed by moving the eccentric?

A. Yes, if the eccentric is moved on the shaft in the same direction in which the engine is to run its range of cut off will be less since this movement of the cam produces earlier lead it produces likewise all events earlier.

39. What do you infer by the angular of advance?

A. The angular of advance is the extreme point of the eccentric with relation to the main pin, or 90 degrees plus lap and lead.

40. What do you infer by the eccentricity of the eccentric cam?

A. The eccentricity of the cam is the path the cam will travel in at its extreme throw, for instance,

from the center of the axle to the outer extremity of the cam say measures 3 inches the path of this point is 3 each way back and forth, producing a 6-inch travel which is termed the eccentricity.

41. Name the points of the stroke of an engine and their order.

A. Admission cut off expansion, release and compression.

42. Why are side and main rods made I shaped instead of solid sections?

A. By rules of physics it shows that the metal removed from the rods would be of no value under the stresses imposed upon them, and by the particular design resistance to breakage is set up under a much-reduced weight compared with the solid rod and giving the same strength.

43. What other advantage is gained by making the rod in this manner?

A. The centrifugal force of which is a bad feature is materially reduced and consequent reductions in counterbalances.

44. What is piston clearance?

A. Piston clearance is the space measured between the piston and cylinder heads taken when the engine is on its dead centers.

45. What is total clearance and how measured?

A. Total clearance is the space between the cylinder head piston and the port up to the valve

seat measured when the engine is on its center. A convenient method used is to pipe up the indicator hole at one end of the cylinder, set the cross head on the dead center, disconnect the valve covering the port on the end of the cylinder that you are to measure with the valve, have these pipes penpendicular and higher than the valve seat. Then take a pail of water, weight and fill the space and note the weight of water it takes to fill this space since 1 cubic foot of water or 1728 cubic inches of water weight 62.4 pounds the total clearance can be accurately measured by the method. The cylinder volume is the product of the area of the circle multiplied by the length of travel of the piston the clearance may be shown in per cent. by dividing the number of cubic inches of cylinder volume into the number of cubic inches of clearance volume.

FINIS.